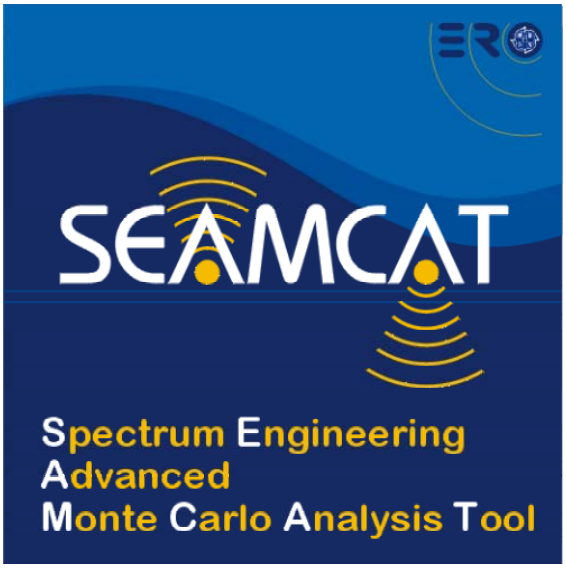

SEAMCAT®

Software Version 2.1

User Manual

European Radiocommunications Office

23 February 2004

This document is intended for introduction to SEAMCAT and working guidance for those who use the programme in their work on assessing the potential interference between different radiocommunication systems. A lot of useful information is also available through the "Help" menu option within the SEAMCAT.

Please visit the SEAMCAT section on the ERO Website (http://www.ero.dk/seamcat) to obtain the latest user information updates, news and for access to freely downloadable software and reference sources.

ACKNOWLEDGEMENT

ERO would like to thank many participating companies and organisations to the SEAMCAT MoU, who made the creation of SEAMCAT tool possible. Special thanks go to their enthusiastic and highly professional staff, in particular active members of SEAMCAT Management Committee (1997-2002) and CEPT SE PT21, whose many contributions formed the main basis of the work in SEAMCAT project in general and the content of this document in particular.

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Table of contents

1 INTRODUCTION 5

1.1 Background to creation of SEAMCAT 5

1.2 About this user manual 5

1.3 Main principles of SEAMCAT 6

1.4 SEAMCAT architecture 7

1.4.1 Event Generation Engine (EGE) 7

1.4.2 Distribution Evaluation Engine (DEE) 8

1.4.3 Interference Calculation Engine (ICE) 8

2 SETTING UP AND RUNNING SEAMCAT 10

2.1 Installing SEAMCAT 10

2.2 Setting up and working with SEAMCAT workspace 10

2.3 Programming interference scenarios 11

2.3.1 Example of co-channel interference between fixed links 11

2.3.2 Example of interference between mobile systems 15

2.4 Notes on using some of SEAMCAT features 18

2.4.1 SEAMCAT libraries 18

2.4.2 Using batch function 19

2.4.3 Choosing the propagation model 22

3 EGE INPUT PARAMETERS 24

3.1 Window Victim link/General 24

3.2 Window Victim link/Victim receiver 24

3.2.1 Tab sheet Victim link/Victim receiver/General 24

3.2.2 Tab sheet Victim link/Victim receiver/Antenna 26

3.3 Window Victim link/Wanted transmitter 26

3.3.1 Tab sheet Victim link/Wanted transmitter/General 26

3.3.2 Tab sheet Victim link/Wanted transmitter/Antenna 26

3.4 Window Victim link/Wt-Vr path 26

3.4.1 Tab sheet Victim link/Wt-Vr path/Relative location 27

3.4.2 Tab sheet Victim link/Wt-Vr path/Propagation Model 28

3.5 Window Interfering Link/General 28
3.6 Window Interfering Link/Interfering transmitter 28
3.6.1 Tab sheet Interfering link/Interfering transmitter/General 28
3.6.2 Tab sheet Interfering link/Interfering transmitter/Antenna 29
3.7 Window Interfering Link/Wanted receiver 29
3.7.1 Tab sheet Interfering link/Wanted receiver/General 29
3.7.2 Tab sheet Interfering link/Wanted receiver/Antenna 30
3.8 Window Interfering link/It-Wr path 30
3.8.1 Tab sheet Interfering link/It-Wr path/Relative location 30
3.8.2 Tab sheet Interfering link/It-Wr path/Propagation Model 31
3.9 Window Interfering link/It-Vr path 31
3.9.1 Tab sheet Interfering link/It-Vr path/Relative location 32
3.9.2 Tab sheet Interfering link/It-Vr path/Propagation Model 33
3.10 Simulation control 33
4 ICE CONTROL PARAMETERS 35
5 MEANING OF SEAMCAT ERROR MESSAGES 36
ANNEX 1: TO DEFINE A DISTRIBUTION OR A FUNCTION 39
ANNEX 2: DEFINITION OF ANTENNA HEIGHT, POINTING AZIMUTH AND ELEVATION 42
ANNEX 3: DEFINITION OF PATH AZIMUTH 43
ANNEX 4: DEFINITION OF RECEIVER SELECTIVITY AND BLOCKING ATTENUATION 44
ANNEX 5: DEFINITION OF ANTENNA PARAMETERS 48
ANNEX 6: DEFINING COVERAGE RADIUS 49
ANNEX 7: SEAMCAT PROPAGATION MODELS 52
ANNEX 8: CALCULATION OF INTERFERENCE SIMULATION RADIUS 69
ANNEX 9: CALCULATION OF DESIRED (*DRSS*) AND INTERFERING (*IRSS*) SIGNALS 70
ANNEX 10: CALCULATION OF UNWANTED EMISSIONS 76
ANNEX 11: CALCULATION OF PROBABILITY OF INTERFERENCE 80
ANNEX 12: POWER CONTROL FUNCTION 82
ANNEX 13: USE OF DBC ATTENUATION UNITS 83
ANNEX 14: DOCUMENT HISTORY 86

1 Introduction

1.1 Background to creation of SEAMCAT

The radio spectrum is a limited resource and can only be used optimally if compatibility is assured between radio systems located in the same or adjacent frequency bands. For example, an important criterion for radio compatibility is the difference between the wanted and unwanted signal levels in the victim receiver input. This parameter is used to derive a separation between the victim and interfering systems or services in geographical space or frequency domains. Considering only the adjacent bands, the most significant interference mechanisms are the unwanted emissions from the transmitters as well as blocking and intermodulation in the victim receiver.

The classical approach for the estimation of these interference mechanisms is the Minimum Coupling Loss (MCL) method. However the essentially analytical MCL method appears being too rigid and difficult to implement in many cases, where operation of radiocommunications systems may not be described in static terms, e.g. random nature of operation of user terminals in the mobile systems. While compromise in such cases may be found by making certain (pessimistic) assumptions and simplifications on the operation of the considered systems, this may produce unnecessarily stiff and static interference assessment, which becomes often biased towards one of the considered systems depending on the partiality of assumptions/simplifications made.

Within the frame of the CEPT Working Group Spectrum Engineering, a new statistical simulation model has been developed based on the Monte-Carlo method, named SEAMCAT® (Spectrum Engineering Advanced Monte-Carlo Analysis Tool). This model and its supporting software implementation allow quick yet reliable consideration of spatial and temporal distributions of the received signals and the resulting statistical probability of interference in a wide variety of scenarios. It therefore enables more precise mutual positioning of those considered systems, hence more efficient use of the radio spectrum.

1.2 About this user manual

This User Manual covers the following points:

- Explanation of general principles and architecture of the software,
- A simple example of setting up and running SEAMCAT simulation;
- Description of principles and key algorithms (signal level calculations + interference probability calculations) necessary for a good understanding of SEAMCAT simulations,
- Explanation of all input parameters of the software in detail and their function.

This manual complements the description of the Monte-Carlo method given in ERC Report 68 (see www.ero.dk for the latest edition of that report).

The following Symbols and formatting conventions are used throughout this document:

- Denotes important note,

"Workspace/New" - Denotes reference to SEAMCAT menu option or parameter input field,

S - Means input value in scalar form,

D - Means input in the form of distribution (see Annex 1 on how to input a distribution),

F - Means input in form of a function as a set of corresponding (X, Y) value pairs.

1.3 Main principles of SEAMCAT

The Monte-Carlo simulation method is based upon the principle of taking samples of random variables, using their defined probability density functions (for simplicity called "distributions" in the SEAMCAT environment). Hence, first a user defines the distributions of possible values of the parameters of considered radiocommunication systems (e.g. antenna heights, powers, operating frequencies, positions of the transceivers, etc.) and then, the SEAMCAT uses those distributions to generate random samples (also called trials or snapshots) of subject parameters. Afterwards for each trial SEAMCAT calculates the strength of the interfering and the desired signals and stores them in data arrays.

As a final step, the SEAMCAT derives the probability of interference taking into account the quality of the receiver in a known environment, and the calculated signals.

In such manner, the SEAMCAT can address virtually all radio interference scenarios in both co-channel (sharing) and adjacent frequency (compatibility) interference studies. This flexibility is achieved by the way the system parameters are defined as variable (or constant) through their distribution functions. It is therefore possible to model even very complex situations by relatively simple elementary functions.

A number of various radiocommunications services can be modeled using SEAMCAT, such as:

- broadcasting (terrestrial systems and ground components of satellite systems),
- mobile (terrestrial systems and ground components of satellite systems),
- point-to-point fixed,
- point-to-multipoint fixed.

It should be noted that the current version of SEAMCAT allows calculating interference only on terrestrial paths, therefore only ground components of satellite systems may be considered at this stage, and only in terms of their mutual interference with the corresponding terrestrial systems.

The SEAMCAT may be used to address the following issues in spectrum engineering:

- Sharing and compatibility studies between different radiocommunications systems operating in the same or adjacent frequency bands,
- Evaluation of transmitter and receiver masks,
- Evaluation of limits for certain system parameters, such as unwanted emissions (spurious and out-of-band), blocking or intermodulation levels.

1.4 SEAMCAT architecture

The architecture of SEAMCAT software is composed of three main processing engines, which perform processing of input data in a sequential order:

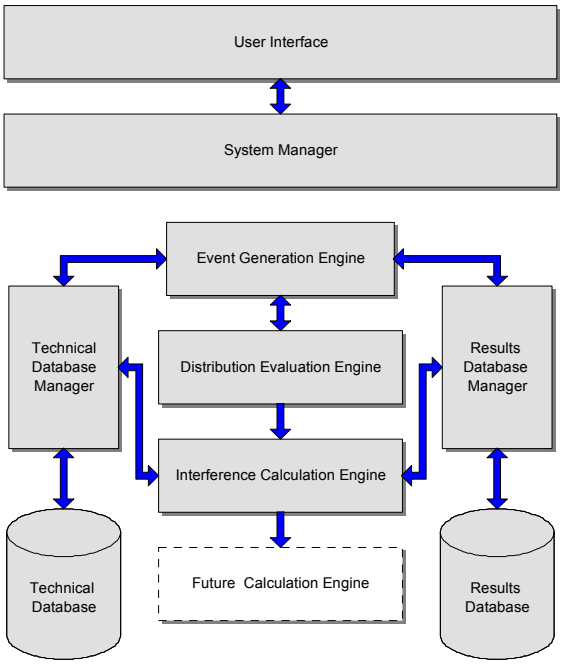


FIGURE 1: ARCHITECTURE OF SEAMCAT

These three main computational engines are described in more detail in the following sub-sections. Several other program modules are used for data storage, user interface and computation management functions.

1.4.1 Event Generation Engine (EGE)

This is the first stage of calculation process, initiated after completion of entering the considered interference scenario. The EGE generates random values for the parameters with set distributions, and then processes them to calculate:

- the **d**esired **R**eceived **S**ignal **S**trength (dRSS), which is the strength of the desired signal received at the **V**ictim **R**eceiver (VR) from the **W**anted **T**ransmitter (WT), as if there was no interference at all,

- the **i**nterfering **R**eceived **S**ignal **S**trength (iRSS), which is the strength of a signal from the **I**nterfering **T**ransmitter (IT) received at the VR (see figure 2). Interfering transmitter has a peer **W**anted **R**eceiver (WR) and the signal from IT to WR may be calculated by the program, e.g. to control the Power Control function at the IT.

This process is repeated *N* times, where *N* is the number of trials, chosen by the user. Generated samples of the desired and all interfering signals are stored in separate data arrays of length *N*.

There are three major interference mechanisms considered by SEAMCAT:

- emissions of the interferer, including unwanted emissions,

- blocking of the victim receiver,

- intermodulation between two interferers.

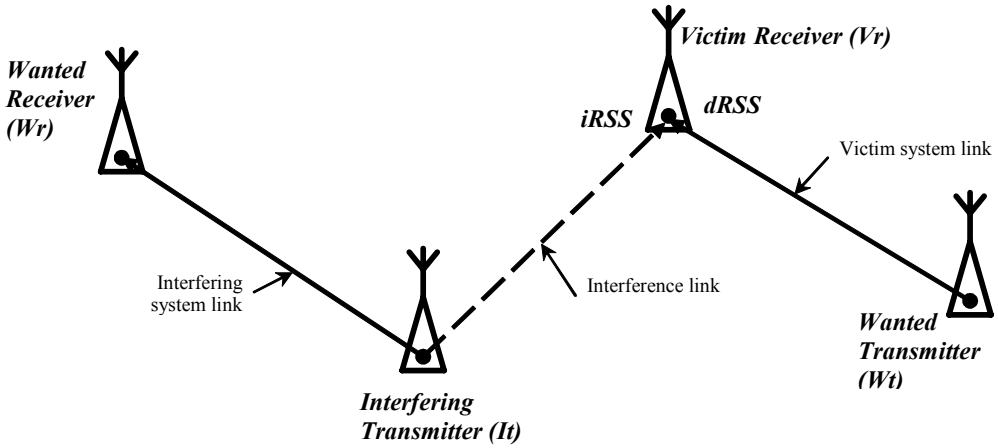


FIGURE 2: VICTIM AND INTERFERING TRANSCEIVERS AND LINKS

More than one interfering system can be considered in SEAMCAT scenario. For example, for intermodulation at least two different systems have to be taken into account.

1.4.2 Distribution Evaluation Engine (DEE)

The Distribution Evaluation Engine (DEE) takes arrays of dRSS and iRSS values generated by the EGE and process this data in order to:

- assess whether or not the number *N* of samples is sufficient to produce statistically stable results,
- calculate correlation (see section 3.10) between:
  - the dRSS and iRSS,
  - the different types of iRSS, e.g. blocking vs. unwanted emissions,
  - if possible, find a known continuous distribution, which would best fit the generated vector of N discrete samples. This information is then transferred to further stages of the programme for information.

The EGE uses some well-known goodness-of-fit algorithms for general distributions, such as Chi-squared test.

When setting the *Simulation Control - DEE driven* option, the programme attempts to ensure the statistical stability of results by instructing DEE to make two successive evaluations of inputted discrete distributions using *N* and (*N*-d*N*) sample sizes. If DEE detects unacceptable variations in discrete distribution, the EGE is instructed to generate another d*N* of additional samples. This test is repeated until a tolerable variation of the parameters is measured over the pre-defined number of successive tests.

1.4.3 Interference Calculation Engine (ICE)

The Interference Calculation Engine (ICE) is the ultimate part of the SEAMCAT architecture. In it, the information generated by the EGE and further processed by DEE is used to calculate the actual probability of interference.

The ICE generates new samples from the arrays or the distributions produced by the DEE, and then evaluates for each of the samples whether the victim receiver suffers interference or not.

This probability can be calculated for three different interference types as a function of the interference criteria, e.g. C/(N+I) *(wanted signal-to-noise & interference)*:

- unwanted emission level from each transmitter of each interfering link,

- victim receiver's response to blocking interference,
- victim receiver's rejection for intermodulation interference.

Two modes of operations are implemented for the ICE module:

- **Compatibility**
  This mode provides a single-figure estimate of the probability of interference in a given interference scenario;
- **Translation**
  This mode calculates probability of interference as a function of one of the three following parameters:
  - Power supplied by the interfering transmitter,
  - Blocking response level of the victim receiver,
  - Intermodulation rejection level for the victim receiver.

When intending to use the ICE Translation mode, the following parameters must initially be set constant in SEAMCAT simulation scenario:

- victim receiver's blocking response,
- victim receiver's intermodulation rejection,
- power distribution of interfering transmitter,
- unwanted emissions floor for interfering transmitter.

The SEAMCAT checks these parameters before starting the simulation and issues appropriate warning message if some of these parameters are not constant.

The ICE uses either of three calculation algorithms, choice depending on the type of output from previous modules. See the Annex 11 of this manual and Annex 4 of ERC Report 68 for detailed description of ICE algorithms.

2 Setting up and running SEAMCAT

This section provides a step-by-step introduction to setting up and running the SEAMCAT software. The section is oriented mostly towards the new users; however the last sub-section "Using additional features" might be also useful for more advanced users, who want to make use of those more sophisticated SEAMCAT functions.

2.1 Installing SEAMCAT

SEAMCAT software is distributed free of charge by the ERO and may be downloaded from the ERO Website at http://www.ero.dk/ . The downloadable file is a zipped archive of original installation files, which may be extracted using generally available WinZip software. The total size of the downloadable zipped file is around 6 MB. In case of problems with downloading a file of such size, please contact the ERO for assistance.

When extracting the installation files into some temporary directory on your PC, the files will be placed in a structure of sub-directories, resembling a set of the 1.44 MB installation diskettes. The installation of SEAMCAT may be then started by running the SETUP.EXE file, located in the subdirectory "Disk1". For first time installations, it is recommended to choose the "Typical" installation option, when prompted by the installation programme.

Upon completion of the installation process, the SEAMCAT window will appear, containing the programme launch icon as well as an icon for the SEAMCAT help file.

2.2 Setting up and working with SEAMCAT workspace

SEAMCAT organises all its input and output information in a so called "workspace", which may be seen both as operating environment for given study and as a file, storing the interference scenario with all input data as well as simulation results.

Every time the SEAMCAT programme is launched, it opens in a blank mode with only Library control window active. Therefore, the first step for the user before any actual work with SEAMCAT is started is to create a new workspace or open some previously created. This is done by selecting menu option "*Workspace/New*" or "*Workspace/Open*". The latter option will be available only when the programme is used not for the first time and there are some workspaces saved from previous work sessions. An example of the SEAMCAT workspace interface is presented in Fig. 3.

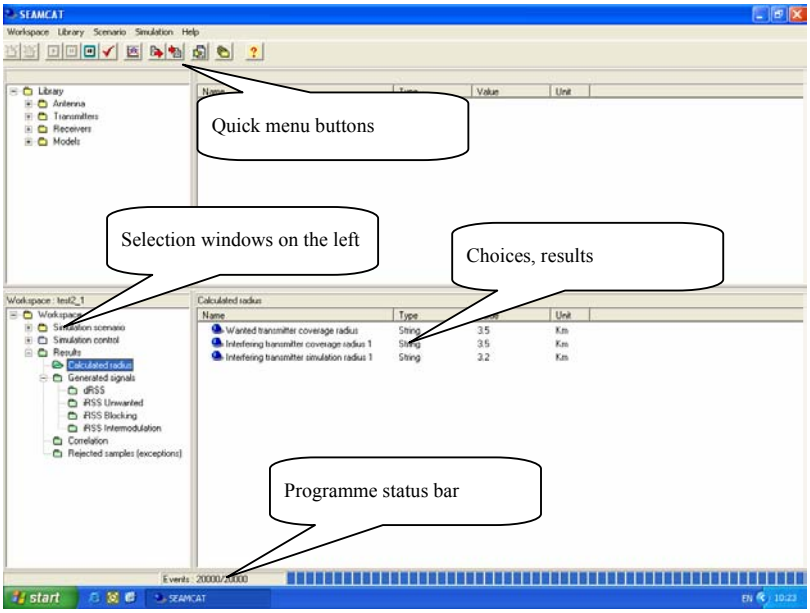


FIGURE 3: EXAMPLE OF SEAMCAT WORKSPACE INTERFACE

It may be seen from Fig. 3 that the workspace interface is organised in several windows, with the left pans depicting the hierarchical structure of available information, where user may browse towards needed subject, and on the right, pans

providing the available choices (data entries) for review. To see the results for vector entries, the user should double click on that entry appearing in the right-hand window.

When the SEAMCAT programme is terminated, it automatically stores the scenario and results (if simulation had been carried out) in the active workspace, so that the work may be continued after re-launching the programme and opening the relevant workspace.

2.3 Programming interference scenarios

After creating a workspace, the user should proceed with defining the interference simulation scenario. This may be done either by:

- importing a previously created and saved scenario via the "*Scenario/Import Scenario*" menu option,
- entering the new scenario manually.

The following sub-sections describe how to enter the interference scenario manually, based on two simple examples.

When new workspace is created, it is being automatically assigned a certain default scenario, which describes a particular interference case with mobile systems working at 900 MHz. Therefore, literally, any process of entering scenario is actually a process of modifying the pre-programmed default one.

2.3.1 Example of co-channel interference between fixed links

Consider a simple interference scenario between two fixed links, graphically depicted in Fig. 4 below.

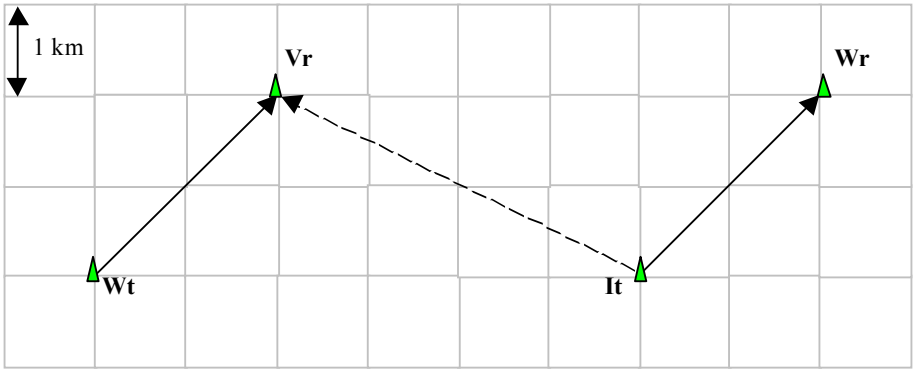


FIGURE 4: FIRST EXAMPLE SCENARIO WITH FIXED LINKS

This scenario may be programmed in the following manner:

- "*Scenario/Victim Link*":
  - "*General/Frequency*" enter Constant=1000 MHz;
  - "*Victim receiver/General/Reception Bandwidth*" enter 25 kHz;
  - "*Victim receiver/General/Antenna pointing*" enter "*Antenna height*" Constant=1.5 m;
  - "*Victim receiver/Antenna/Antenna peak gain*" enter 9 dBi (patterns unchecked, meaning non-directional);
  - "*Wanted transmitter/General/Power*" enter Constant=30 dBm;
  - "*Wanted transmitter/General/Antenna pointing*" enter "*Antenna height*" Constant=1.5 m;
  - "*Wanted transmitter/Antenna/Antenna peak gain*" enter 9 dBi (non-directional);

- "*Wt->Vr path/Relative location*" check "*Correlated distance*", enter dX=2 km, dY=2 km;
- "*Wt->Vr path/Propagation model*" select "*Free space*".

- "*Scenario/Interfering Links*", highlight the name of the link and choose "*Edit*", then:
  - "*General/Frequency*" enter Constant=1000 MHz;
  - "*Interfering transmitter/General/Power*" enter Constant=30 dBm;
  - "*Interfering transmitter/General/Unwanted emissions mask*" enter (0.009 MHz, 0 dBc, 30 kHz), (0.0125, -30, 30), (0.025, -45, 30), (1, -60, 30), then press "*Sym*(metry)" to get the symmetrical mask, see Fig. 5 below;
  - "*Interfering transmitter/General/Antenna pointing*" enter "*Antenna height*" Constant=1.5 m;
  - "*Interfering transmitter/Antenna/Antenna peak gain*" enter 9 dBi (non-directional);
  - "*It->Vr path/Relative location*" select mode "*Itx->Vrx*", enter dX=4 km, dY=-2 km;
  - "*It->Vr path/Propagation model*" select "*Free space*".

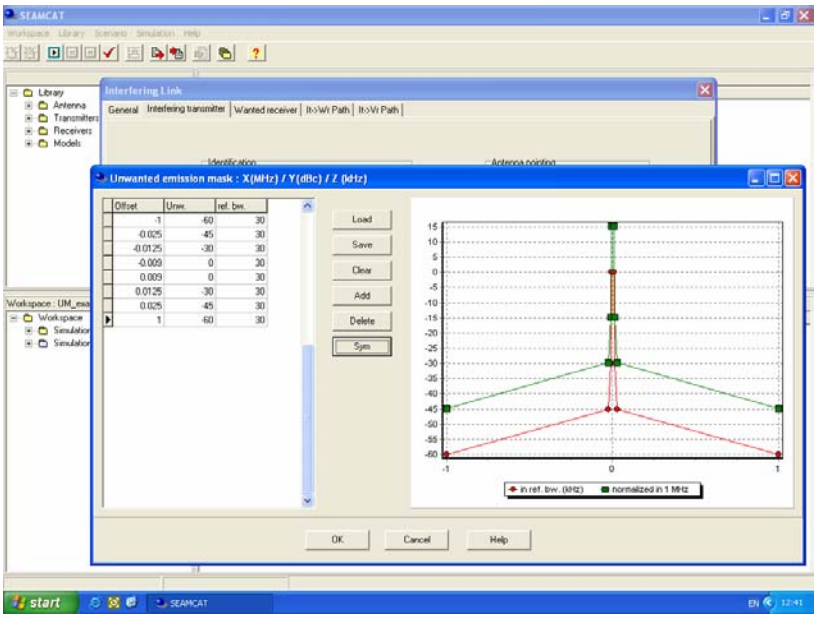


FIGURE 5: ENTERING UNWANTED EMISSIONS MASK

The rest of the scenario input parameters may remain unchanged with the default values.

Important to note that the SEAMCAT may consider scenario with several interfering links. Additional interfering links may be added in the link selection window appearing after selecting menu option "*Scenario/Interference links*", and then "Add" or "Duplicate".

Having finalised entering the scenario, it is then possible to proceed with simulations. This is done by choosing the menu option "*Simulation/Start*". During the simulation process, the status bar shows the different steps of the simulation and the progress indicator.

After completing the simulations, the "Results" directory appears in the bottom left window, which may be then browsed for the particular results of calculations. For example, for the above described scenario simulation would produce the generated useful field strength (dRSS) as depicted in Fig. 6 below and unwanted interfering field strength (iRSS) as depicted in Fig. 7.

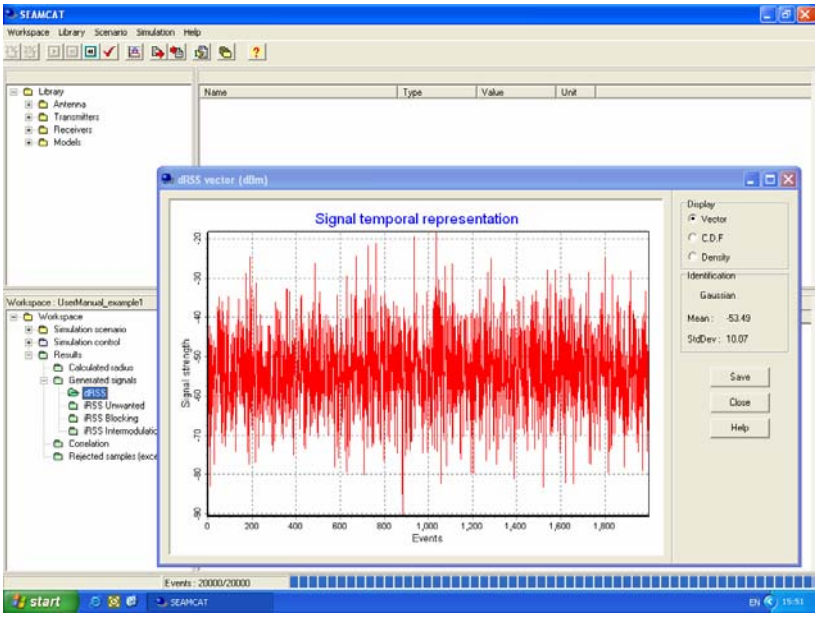


FIGURE 6: FIRST EXAMPLE - SIMULATION RESULTS: dRSS VECTOR

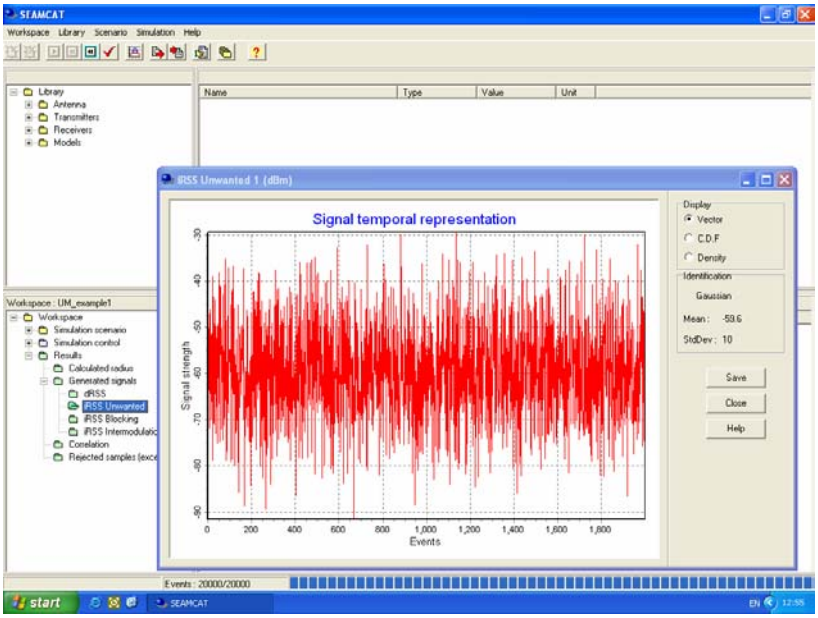


FIGURE 7: FIRST EXAMPLE - SIMULATION RESULTS: iRSS VECTOR

It may be seen from these results that the dRSS mean value is around -53 dBm, and for iRSS the value is around -59 dBm. These are the results produced after the operation of EGE (see Section 1.4).

The summation vectors listed for different iRSS signals are intended to show the sum of all the individual iRRS signals when several interfering links are considered. If only one interfering link is modelled, as in this example, the summation vector is identical to the only single iRSS vector present.

Now it is possible to proceed to the next step and evaluate the actual interference potential. This is done by using the menu option "*Simulation/Interference calculation*". Selecting this option produces the interference calculation window, which essentially controls the operation of SEAMCAT's ICE. Using the default calculation controls and pressing the "*Start*" button for this example would produce estimation of the probability of interference at 82%, see Fig. 8.

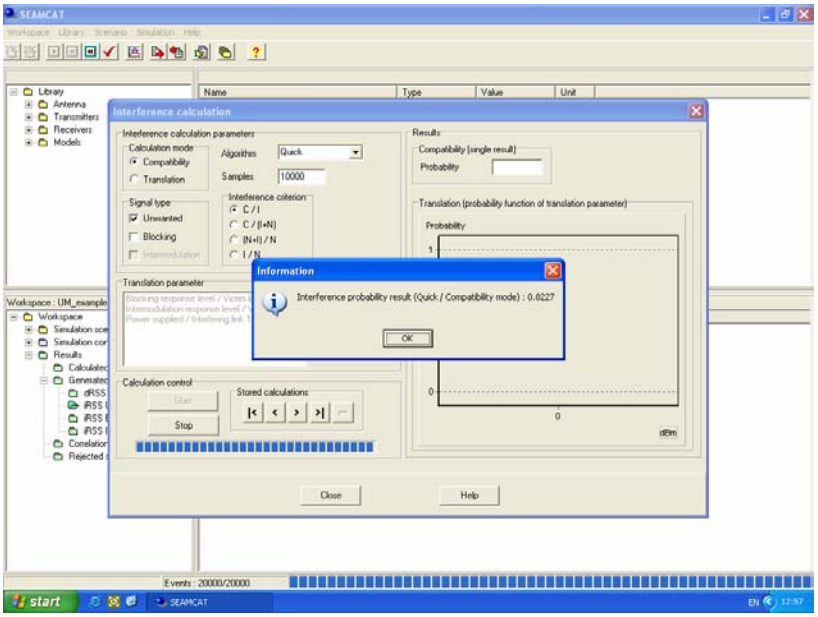


FIGURE 8: FIRST EXAMPLE - CALCULATION OF INTERFERENCE PROBABILITY

The same interference calculation window may be used to perform further analysis, e.g. consider dependence of the probability of interference on some of the input parameters. For example, considering the impact of power of interfering transmitter (It) may be done by selecting "*Calculation mode/Translation*", and then selecting the "*Translation parameter/Power Supplied*" with the appropriate minimum and maximum values. Performing this analysis for the given example produces the curve as shown in Fig. 9.

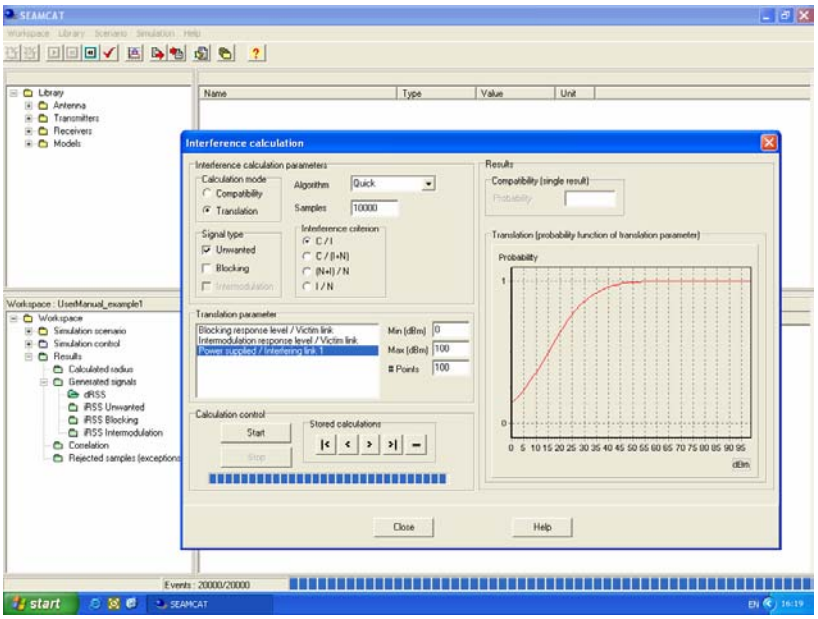


FIGURE 9: FIRST EXAMPLE - INTERFERENCE PROBABILITY IN TRANSLATION MODE

Using such translation mode calculation allows making a decision as to what maximum value of the subject parameter (e.g. output power of interfering transmitter) could be allowed while not exceeding the acceptable probability of interference.

It may be noted that in this case of interference between fixed links, the variation of received signals and hence the statistical nature of calculated probability of interference is due only to the variation of the calculated path loss. If for the same scenario one would uncheck now the "*Variation*" option for the selected free space propagation model in both the victim and interfering link scenario windows, the calculated dRSS and iRSS signals would be flat and the

probability of interference would be estimated at 1. If in this case applying the Translation Mode of interference calculation, the result would be a step function, as shown in Fig. 10.

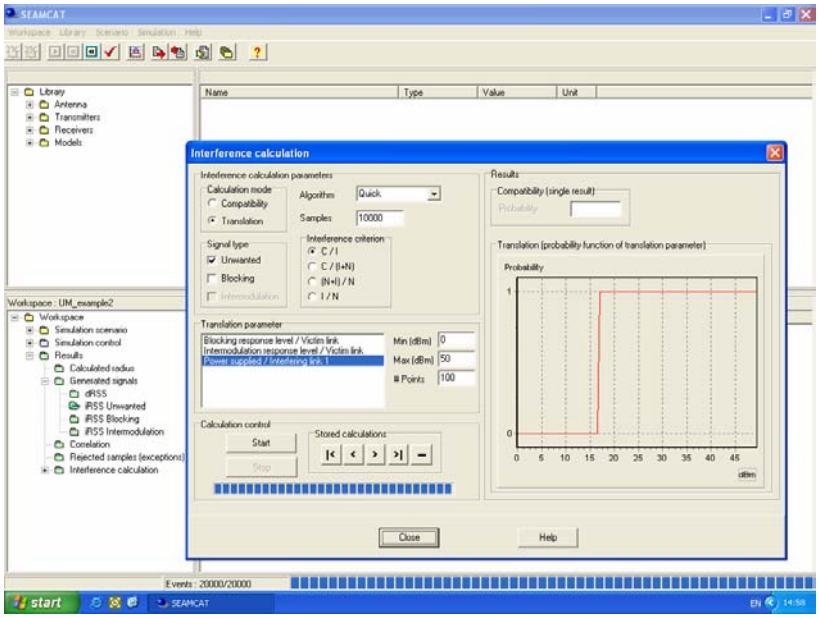


FIGURE 10: PROBABILITY OF INTERFERENCE WHEN NO VARIATIONS OCCUR

In this case shown in Fig. 10, the probability of interference changes from 0 to 1 when the power of the interfering transmitter and resulting iRSS become large enough to exceed the C/I set limit.

In other typical modelled radiocommunication systems, the calculated signals and, subsequently, the probability of interference will have statistically varying nature due to the operating pattern of the considered systems, e.g. movement of mobile stations in the mobile service systems, random change of their operating parameters (e.g. frequency), etc, as shown in the following example.

2.3.2 Example of interference between mobile systems

This section describes a more complex example scenario of interference into a base station (BS) of a multi-channel mobile system from the mobile stations (MS) of another mobile system with single overlapping channel. This scenario is depicted in Fig. 11.

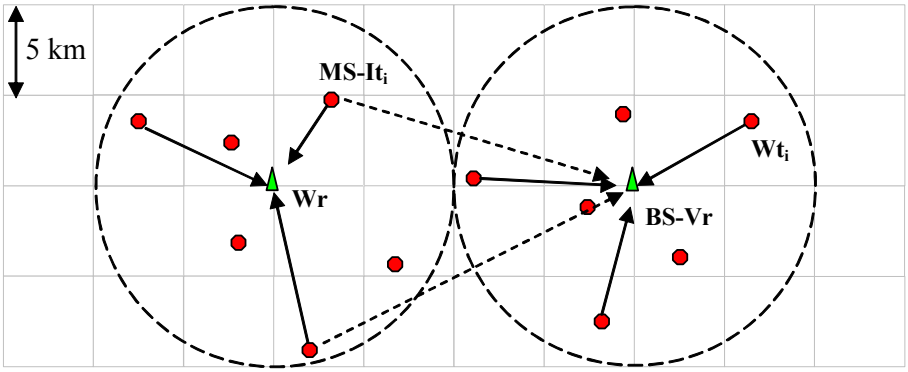


FIGURE 11: SECOND EXAMPLE SCENARIO WITH MOBILE SYSTEMS

This scenario may be programmed by making the following changes to the previous scenario example:

- "*Scenario/Victim Link*":

- ☞ "*General/Frequency*" select User Defined Stair distribution, enter following pairs to describe the CDF: (450 MHz; 0.2), (450.025 MHz; 0.4), (450.05 MHz; 0.6), (450.075 MHz; 0.8), (450.1 MHz; 1) – this would make the victim link frequency hopping at equal probability between those five specified centre frequencies;

- ☞ "*Victim receiver/General/Reception Bandwidth*" remains 25 kHz;

- ☞ "*Victim receiver/General/Antenna pointing*" enter "*Antenna height*" Constant=30 m;

- ☞ "*Victim receiver/Antenna/Antenna peak gain*" enter 15 dBi (non-directional);

- ☞ "*Wanted transmitter/General/Power*" remains 30 dBm, "*Antenna height*" remains 1.5 m;

- ☞ "*Wanted transmitter/Antenna/Antenna peak gain*" enter 0 dBi (non-directional);

- ☞ "*Wt->Vr path/Relative location*" - uncheck "*Correlated distance*", enter "*Path azimuth*" Uniform=0…360^{o}, "*Path distance factor*" Uniform=0.1…1, "*Coverage radius*" enter User defined=10 km;

- ☞ "*Wt->Vr path/Propagation model*" select "*Extended Hata*".

- "*Scenario/Interfering Links*":

  - ☞ "*General/Frequency*" enter Constant=450.100 MHz (i.e. coincide with the last 5th channel of victim link);

  - ☞ "*Interfering transmitter/General/Power*" enter Constant=42 dBm (e.g. vehicle mounted MSs);

  - ☞ "*Interfering transmitter/General/Unwanted emissions mask*" remains as entered in 1st example, see Fig. 5;

  - ☞ "*Interfering transmitter/General/Antenna pointing*" - "*Antenna height*" remains 1.5 m;

  - ☞ "*Interfering transmitter/Antenna/Antenna peak gain*" enter 5 dBi (non-directional);

  - ☞ "*It->Wr path/Relative location*" - uncheck "*Correlated distance*", enter "*Path azimuth*" Uniform=0…360^{o}, "*Path distance factor*" enter Uniform=0.1…1, "*Coverage radius*" enter User defined=10 km;

  - ☞ "*It->Vr path/Relative location*" select mode "*Wrx->Vrx*", enter dX=-20 km, dY=0 km;

  - ☞ "*It->Vr path/Relative location*" select mode "*Wrx->Vrx*", enter dX=-20 km, dY=0 km;

  - ☞ "*It->Vr path/Propagation model*" select "*Extended Hata*".

Having completed entering this scenario, the simulation would produce the mean values of dRSS at around -72 dBm and iRSS≈-113 dBm. But while the dRSS signal would closely match the Gaussian distribution type, the iRSS signal density would have an unusual two-peak pattern, as shown on Fig. 12. The first (higher probability) peak at around -120 dBm corresponds to the cases when victim link dwelled on channels not coinciding with the interferer's frequency 450.1 MHz, thus the signal level is lower thanks to transmitter filter discrimination (see Fig. 5). Then the second peak exhibiting lesser probability but higher iRSS values of around -80 dBm is due to the instances when victim link frequency jumped co-channel with that of the interfering link. The spread of the signal around the peaks is due to the impact of different path losses and fading variations for different trialled positions of MS around the subject BS.

Note, that the different modes of displaying the signal vector are selectable in the "*Display*" field on the upper-right side of the window. The Fig. 12 shows the view with selected "*Density*" option.

Then proceeding to the interference calculation stage, the above scenario yields the high probability of interference at around 17.5%, apparently due to the impact of instances of co-channel interference. It is possible to see immediately whether change of some of the critical input parameters, such as interfering transmitter's output power would affect the probability of interference. In this case applying the Translation Mode to test the transmitter's power range 0…50 dBm allows to conclude that the interference may be reduced to acceptable levels of few percent only by restricting the output power of the interfering stations to below 10 dBm, see Fig. 13.

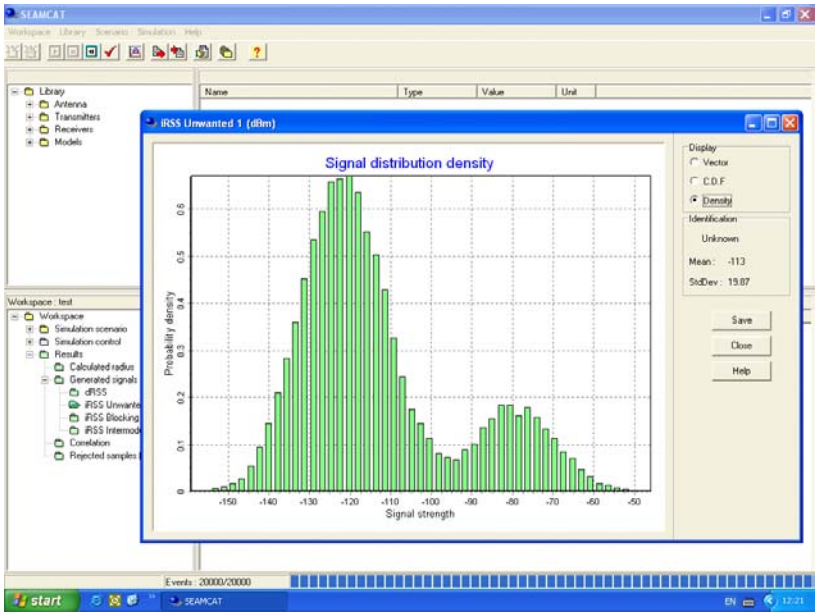


FIGURE 12: SECOND EXAMPLE – SIMULATION RESULTS: iRSS VECTOR

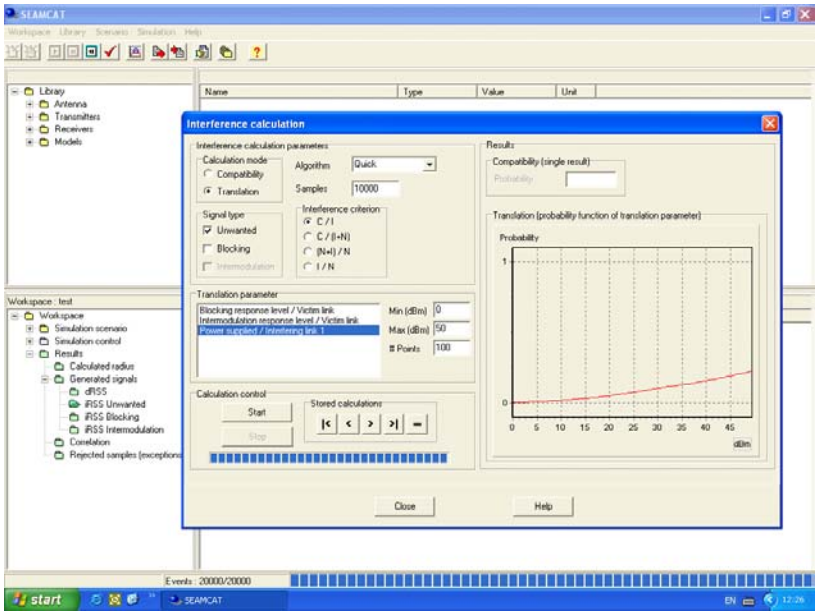


FIGURE 13: SECOND EXAMPLE - INTERFERENCE PROBABILITY IN TRANSLATION MODE

Alternatively, it may be seen that by keeping the interferers' output power but changing the operating frequency to the next adjacent channel (i.e. 450.125 MHz in this case) also allows reducing the probability of interference to below 1%.

The above two examples are a simplistic illustration of the order and logic of SEAMCAT functioning by setting and changing only some of the basic input parameters. Any real analysis would require careful review and proper setting and tuning of all the SEAMCAT scenario input parameters, using the detailed guidance provided in the following section 3.

2.4 Notes on using some of SEAMCAT features

2.4.1 SEAMCAT libraries

SEAMCAT library is a useful tool for creating and storing various typical elements of interference scenario and later using them when creating complex scenarios. The SEAMCAT library allows creating those data templates for the four following elements:

- Antennas - might be useful in particular to store complex radiation patterns);
- Transmitters and Receivers – useful to store detailed descriptions, complex emission plots, etc;
- Propagation models – may be used to create user-defined propagation models, using the special script.

Modification of existing (default) library elements as well as creation of new elements can be managed through the relevant options of "*Library*" menu. Once stored, the library elements may be then easily inserted into the scenario by selecting a particular library element in the "Definition" field for relevant transceiver in any or both the victim and interfering links, see Fig. 14.

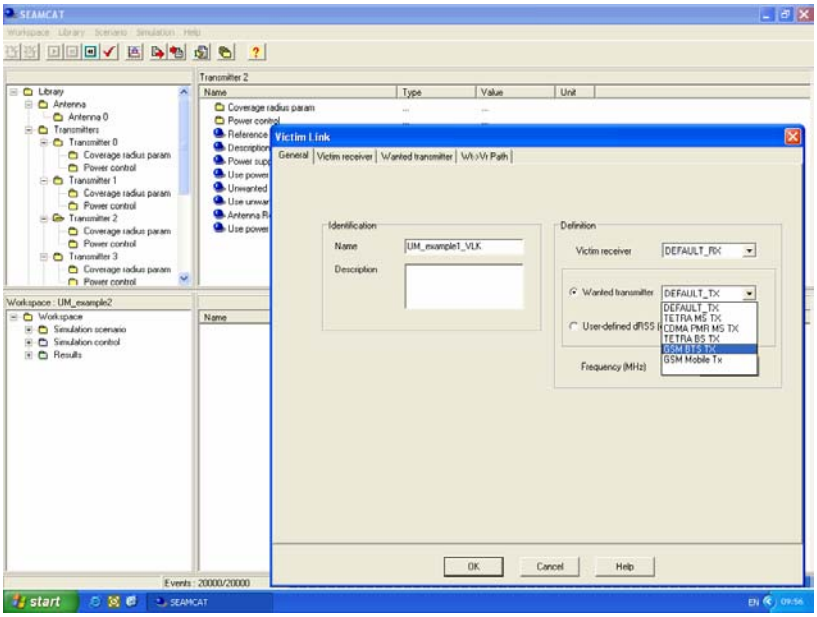


FIGURE 14: SELECTING AN ELEMENT FROM PREVIOUSLY MADE LIBRARY

Note that once a library element is inserted into a given scenario, there remains no logical link between the original library template and its replica in the interfering scenario. That is any later modification or suppression of an original library element doesn't result in any change in previously created simulation workspaces built using that element.

Creation of an extended library of SEAMCAT scenario building blocks is especially useful because the data stored in the libraries may be exchanged, for example within the team of people working with studies that involve similar radiocommunication systems.

Library exchange is done through, first, storing the existing library into an export file by using the "*Library/Export library*" menu option and, then, retrieving the stored library data at the destination from the export file by using the "*Library/Library import*" menu option.

The current version of SEAMCAT does not check the names of import library elements, therefore, if any of the names in the import file match those already in store (usually it occurs with the DEFAULT elements stored both in the export file and in the destination library) import function will malfunction. This may be avoided by manually cross-checking the names of the elements to be imported with those already in store and deleting the duplicating ones. This will be alleviated in future software version.

2.4.2 Using batch function

The batch function allows automation of complex compatibility studies by scheduling several SEAMCAT simulations in one run. This is done through defining one or several parameters (referred "batch parameters") that will have to be varied and then setting up a simulation schedule with instructions on how to change those parameters in several consecutive simulations.

In principle, the batch function is similar to using the Translation mode in interference calculation function (ICE), where it is possible to see the impact of changing one of the three input parameters on the final probability of interference. However, while the Translation mode has only three pre-defined input parameters that may be subject to change, the batch function allows modification of any input parameter and does not limit the number of those parameters subject to change. This is because the batch function re-runs all the simulation (starting from event generations in EGE) completely each time when batch parameter(s) is/are changed. However, this also means that the total calculation time will equal sum of all the individual simulations with each change of batch parameters.

The first step in preparing the batch function is to define the parameters that will be used in the batch calculations:

- select the relevant element of simulation scenario in the lower-left workspace control window pan (e.g. select interfering link);
- then the selection window on the right-hand side will display all the input parameters for selected scenario part;
- in the right-hand side window point the cursor to the element to be changed and click the right mouse button, the pop up menu will appear, now select "*Batch parameter*", as shown in Fig. 15;
- after this, a clock icon will appear next to the selected batch parameter, note "Power supplied" parameter in Fig. 15.

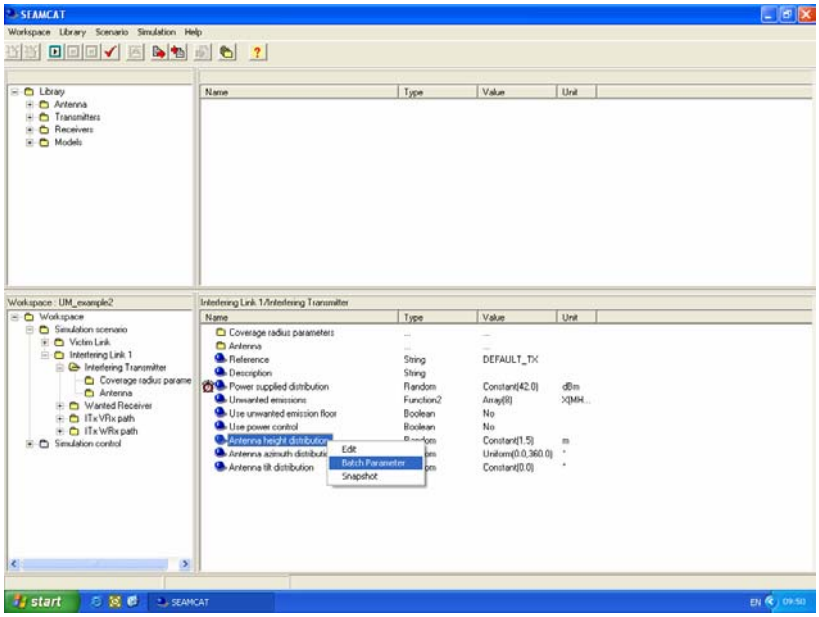


FIGURE 15: DEFINING A BATCH PARAMETER

After marking all input parameters that will be subject to change as batch parameters, the active workspace may be closed. The next step is to create a special batch workspace; for this select the menu option "*Workspace/Batch*" from the top menu list. The batch selection window will appear; it will be empty if batch function is used for the first time. Create a new batch schedule by selecting the "*Add*" button, or open an existing one by highlighting it and pressing "*Edit*" button.

Then the batch-scheduling window will appear, as shown in Fig. 16. Each line on this batch schedule will represent a single simulation with given set of specific input values for the selected batch parameters.

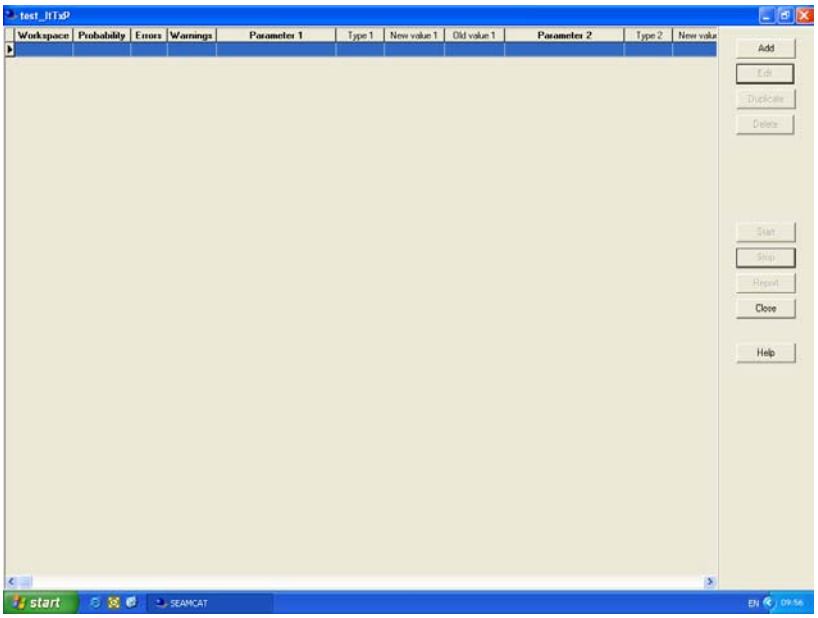


FIGURE 16: SEAMCAT BATCH SCHEDULING WINDOW

Add a simulation to the batch by pressing the "*Add*" button. The "*Batch detail*" window shall appear, as shown on Fig. 17. In the field "*Workspace*" it allows to select the relevant workspace, where the user had previously indicated batch parameters. Then in the parameter selection lines one may choose which exactly of batch parameters will be changed during that particular simulation run, as being done for "*Parameter 2*" in Fig. 17. Once a batch parameter is selected, its value to be assumed in that simulation run may be chosen by pressing the "Value" button next to it.

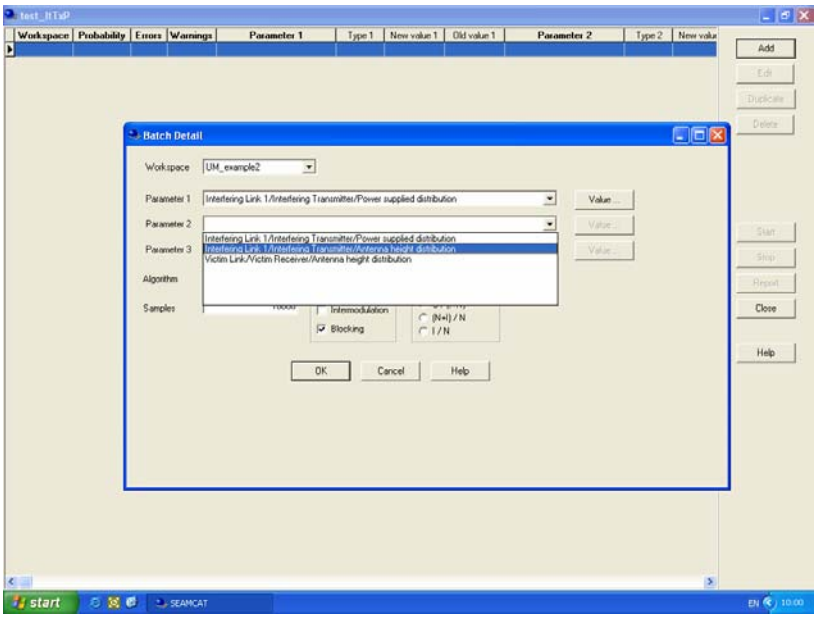


FIGURE 17: DEFINING A SIMULATION ENTRY FOR THE BATCH

After selecting the relevant batch parameters and their values, as well as some of the simulation control parameters in the lower part of the window, the simulation entry may be saved by pressing "OK" button; it will then appear on the schedule list in the main batch window.

This procedure may be repeated unlimited number of times by adding new simulations to the batch schedule until the intended variation of input parameters is fully covered by all batch-entries, see example on Fig. 18 with four scheduled simulations.

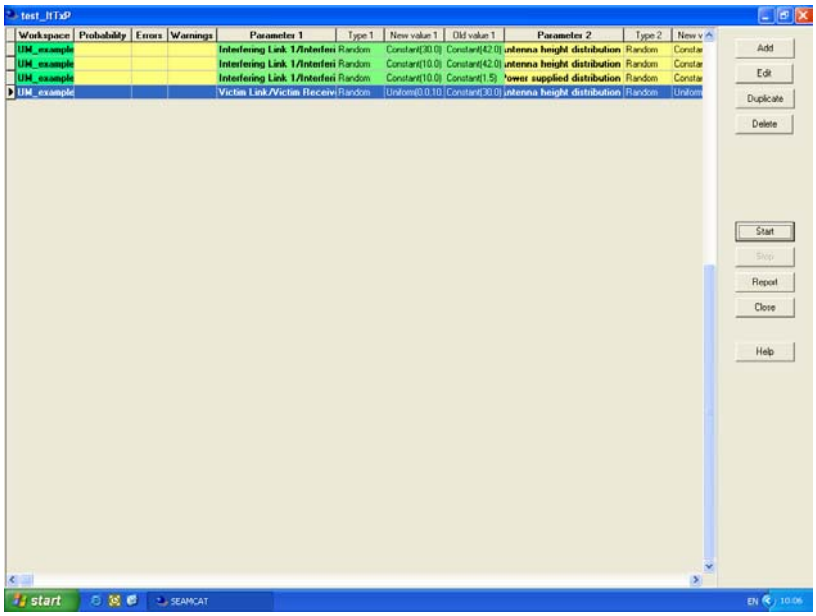


FIGURE 18: A COMPLETED BATCH SCHEDULE WITH SEVERAL VARIED SIMULATIONS

After the batch schedule is completed with all intended simulations, begin the batch simulations by pressing the "*Start*" button. The SEAMCAT will conduct the scheduled simulations one after another; upon completion of work the batch report will be opened, presenting the results of all simulations, as shown in Fig. 19.

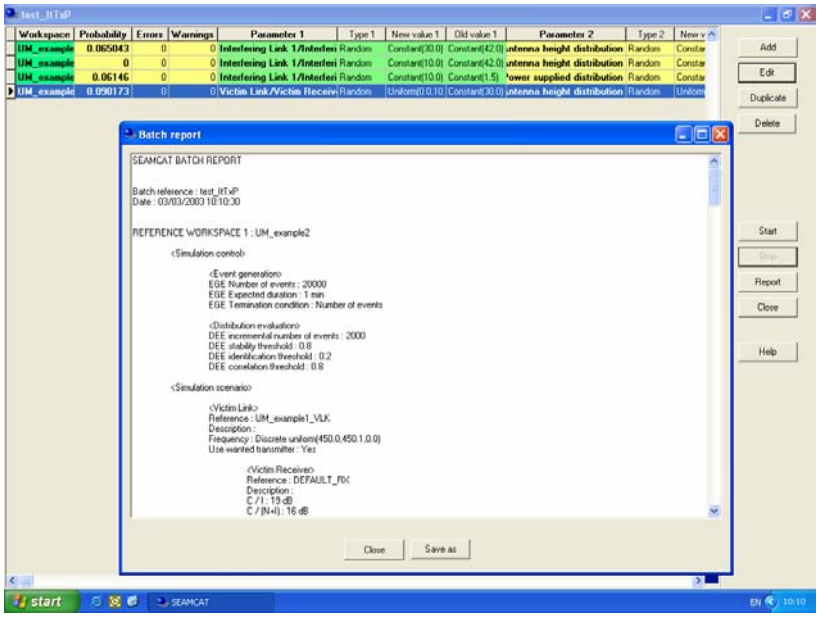


FIGURE 19: REPORT OF BATCH SIMULATIONS

The automatically appearing batch report may be closed, as it is possible to re-open it again later using the "*Report*" button in the batch window, also then it would be possible to change some of the reporting options (format, data presented, etc). After the simulations are completed, the batch window also displays the calculated probability of interference for all scheduled simulations, as also seen on top of Fig. 19.

The batch schedule may be then modified; it may also be saved for future work. When saving the batch after calculations are performed, also the calculation results are stored and may be recalled in a report at a later opening of that batch.

2.4.3 Choosing the propagation model

Selection of the propagation model is very important part of creating the simulation scenario, as the propagation model establishes the propagation loss on modelled radio links – the major parameter in the overall link budget.

The SEAMCAT allows selection of the following generic propagation models:

- Extended Hata model;
- Extended Hata model, corrected for Short Range Device applications environment;
- Spherical diffraction model;
- Free space propagation model;
- ITU-R Recommendation P.1546-0 model;
- A user-defined model.

As an additional value, SEAMCAT allows to select different propagation models for each of the considered radio paths: victim and interfering links and the interference path.

In all cases SEAMCAT does not take into account any path-specific topographic considerations.

The detailed description of the input parameters for these models as well as their calculation algorithms is provided in Annex 7 of this manual.

Selecting the model

It is understood that the selection of the propagation model(-s) will be done at the good judgment of the user, depending on the experience, simulation purposes, type of radio systems and environment considered in the scenario. To aid in the selection process, the following table 1 provides an indication of the application ranges and typical areas of suitability of the models available in SEAMCAT.

Model	Frequency range	Distance range	Typical application area
Extended Hata	30 MHz - 3 GHz	Up to 100 km	Mobile services and similar non-LOS applications
Extended Hata (SRD)	30 MHz - 3 GHz	Up to 100 km	Short range, low antenna height applications
Spherical diffraction	Above 3 GHz	Up-to and beyond radio horizon	Interference between terrestrial radio systems in open (rural) areas
Free space	Above 30 MHz	LOS-limited	Fixed links and other systems with direct LOS
ITU-R P.1546	30 MHz - 3 GHz	1 km – 1000 km	Broadcasting and other terrestrial services. Often referred to in international planning/co-ordination

Table 1: Indicative guide to the selection of propagation models

Comparing the Extended Hata vs. P.1546 models

The two of the available in SEAMCAT models, namely the Extended Hata and the ITU-R Rec. P.1546 models may produce either similar or different results depending on a certain set of conditions. Therefore, when choosing between those two models, the user should be aware of their similarities and differences.

The Hata model was originally developed for the non-Line Of Sight (LOS) urban environment typical of mobile services - that is with low-height mobile terminals moving in cluttered environment. The P.1546 model was originally developed for broadcasting environment (at that time being the ITU-R Rec. P.370), however later was modified into a universal terrestrial propagation model, by approximating between the original P.370 curves and curves of other models, incl. those of Okumura-Hata model. Therefore the P.1546 and Hata models may yield similar results at distances of some 10-40 km (the typical range of Hata model) with the corresponding antenna heights.

By corresponding antenna heights it is meant to draw attention that the Hata and P.1546 models use different definitions of the antennae heights. The P.1546 model assumes that the height of transmitting antenna (H1) is the height above the local clutter, i.e. the effective height of antenna (also with respect to topographical heights along the path if those are considered – not in SEAMCAT). The Hata model assumes the height of transmitting antenna simply above ground. That means that to produce the similar results the height of transmitting antenna in Hata model should be higher than that in P.1546 model by height of surrounding clutter, e.g. by 20 m in urban environment.

On the other hand, it should be noted that the SEAMCAT always applies the correction for receiving antenna height, depending on its height above or below the assumed height of local clutter at the receiving location. The SEAMCAT assumes the height of local clutter to be 10 m for rural and sub-urban environment and 20 m for urban environment. Therefore, to obtain the results similar to those of Hata model, the height of receiving antenna in P.1546 model should be set at the heights comparative to those of assumed height of local clutter. Figures 20 and 21 show a comparison of propagation losses derived by SEAMCAT in-built Extended Hata and P.1546 models with respectively rural and urban setting (frequency 600 MHz, 50% time).

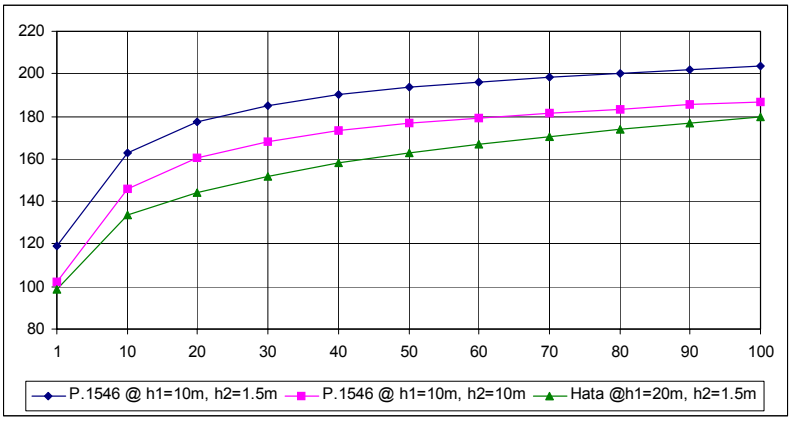


FIGURE 20: COMPARING HATA VS. P.1546 MODEL IN "RURAL" SETTING

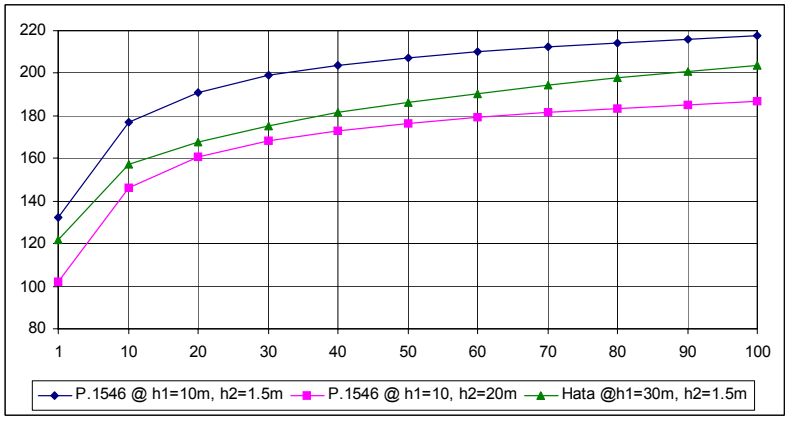


FIGURE 21: COMPARING HATA VS. P.1546 MODEL IN "URBAN" SETTING

Note that the P.1546 curve with 10 m receiving height in rural areas equals with that of P.1546 model curve for urban area with 20 m receiving antenna height. This is because the type of propagation environment (urban, rural) in this model has impact only on the calculation of applied receiver antenna correction.

3 EGE Input parameters

This section lists all the input parameters in SEAMCAT user interface, required to set up a simulation scenario. It also explains the use of these parameters in SEAMCAT calculations, where appropriate.

It should be noted that prior to beginning the simulation, the SEAMCAT checks the consistency and appropriateness of certain input parameters, see section 5 of this manual.

For abbreviations and terminology used in the tables in this section, please consult the section 1 of this manual.

3.1 Window Victim link/General

Description	Symbol	Type	Unit	Comments
Name: name of the victim link				
Description: comments on the link				
Victim receiver: choose in the menu a receiver already defined in the library				Call a receiver already defined in the Library, otherwise type the inputs directly.
Wanted transmitter: choose a transmitter already defined in the library				If **Wanted transmitter** is checked: • Call a transmitter already defined in the Library otherwise type the input directly. • dRSS is calculated taking into account all the Victim link parameters.
User defined dRSS: define a distribution of the desired Received Signal Strength	dRSS	D or S (if constant)	dBm/Vr reception bandw.	If **User-defined dRSS** is checked: • the user defines the dRSS distribution. • tabsheets "Wanted transmitter" and "Wt to Vr Path" disappear. • The **Power control max threshold** option is not available in this case in the "Victim receiver" tabsheet.
Frequency	f_{wt}	D or S	MHz	Distribution of the center frequency of the victim link

Table 2: Victim link/General

3.2 Window Victim link/Victim receiver

Two tab sheets are available:

- general
- antenna

3.2.1 Tab sheet Victim link/Victim receiver/General

Description	Symbol	Type	Unit	Comments
Name: name of the victim receiver				
Description: comments on the receiver				
Antenna height	h	D or S	m	See Annex 2
Antenna azimuth: Antenna alignment horizontal tolerance	δ^H	D or S	degree	This is the angle between the Vr main beam and the direction to Wt. E.g. if antenna azimuth=0, the Vr and Wt antennas are strictly aligned in the horizontal plane, see Annex 2
Antenna elevation: Antenna alignment vertical tolerance	δ^V	D or S	degree	This is the vertical angle between the Vr main beam and the direction towards Wt. E.g. if antenna elevation=0, the Vr and Wt antennas are strictly aligned in the vertical plane, see Annex 2.
Noise floor: define a distribution of the noise floor	N	D or S	dBm/MHz	Distribution of the strength of the noise floor. This parameters is used for the probability calculation when the criteria is C/(N+I) or (N+I)/N.
Blocking response: Receiver frequency response (receiver blocking performance)	*blocking*	F(MHz)	dBm or dB depnd. on mode	Receiver mask attenuation (positive or negative values depending on the chosen blocking mode, see below) versus frequency, see Annex 4.
Blocking attenuation mode				Calculation mode of the of the receiver attenuation, see Annex 4: • **User-defined**: the attenuation due to the receiver selectivity is the blocking mask. In this case, the blocking response is in dB (so input positive values). • **Protection ratio**: the attenuation of the receiver is 3+C/(N+I)+Blocking mask. In this case, the blocking response is in dB (So input positive values). • **Sensitivity**: the user inputs the Blocking mask in dBm (absolute value) which is the maximum acceptable interfering power (dBm).The attenuation of the receiver is C/(N+I)+Blocking mask (dBm)-Sensitivity.
Intermodulation rejection: Inter-modulation response (inter-modulation interference)	*intermod*	F(MHz)	dB	Receiver mask at the intermodulation frequency.
Power control max threshold: (Dynamic range of received power)	Pc_{max}	S	dB reception bandwidth	Maximum range of the receive power that Victim receiver can accept, in terms of the maximum receive power over the Vr's sensitivity threshold. If the trialled dRSS value exceeds ($sens$+Pc_{max}), the dRSS is set to the latter value.
Sensitivity	*sens*	S	dBm/Vr reception bandwidth	Sensitivity of the receiver.
Reception bandwidth: Operating bandwidth	B	S	kHz	Bandwidth of the receiver.

Interference criteria: C/I or C/(N+I) or (N+I)/N: Protection Ratio	*C/I or C/(N+I) or (N+I)/N or I/N*	S	dB	The user defines at least one of these three criteria. (C/I, C/(N+I), (N+I)/N). Then, the user will choose one of these criteria for each interference probability calculation. If more than one of these parameters is defined by the user, SEAMCAT performs a consistency checking between the interference criteria.

Table 3: Victim link/Victim receiver

3.2.2 Tab sheet Victim link/Victim receiver/Antenna

(See Annex 5)

3.3 Window Victim link/Wanted transmitter

Two tab sheets are available:

- general
- antenna

3.3.1 Tab sheet Victim link/Wanted transmitter/General

Description	Symbol	Type	Unit	Comments
Name: name of the victim link				
Description: comments on the link				
Power distribution: Power supplied	P	S or D	dBm/Vr reception bandwidth	
Antenna height	h_{wt}	S or D	m	See Annex 2
Antenna azimuth: Antenna alignment horizontal tolerance	δ^{H}_{wt}	S or D	degree	This is the angle between the Wt main beam and the direction towards Vr. E.g. if antenna azimuth=0, the Vr and Wt antennas are strictly aligned in the horizontal plane, see Annex 2.
Antenna elevation: Antenna alignment vertical tolerance	δ^{V}_{wt}	S or D	degree	This is the vertical angle between the Wt main beam and the aligned direction towards Vr. E.g. if antenna elevation=0, the Vr and Wt antennas are strictly aligned in vertical plane, see Annex 2.

Table 4: Victim Link/Wanted transmitter

3.3.2 Tab sheet Victim link/Wanted transmitter/Antenna

(See Annex 5)

3.4 Window Victim link/Wt-Vr path

Two tab sheets are available:

- relative location
- propagation model

3.4.1 Tab sheet Victim link/Wt-Vr path/Relative location

- Correlation case: position between the receiver and the transceiver is defined using Cartesian coordinates.

Description	Symbol	Type	Unit	Comments
Correlation distance				Checked
Delta X, delta Y	X Y	S	km	Distance between the transmitter and receiver in the Victim link.

Table 5: Victim Link/Wt-Vr correlation case

- Uncorrelated case: A coverage radius is calculated. Three different modes are available for calculating the maximum radius R_{max}^{wt} (see Annex 6). The Victim receiver will be randomly deployed within the area centred on the Wanted transmitter and delimited by the maximum radius R_{max}^{wt}.

Description	Symbol	Type	Unit	Comments
Correlation distance				Unchecked
Path azimuth		D or S	Degrees	Horizontal angle for the location of the Vr respect to the Wt, see Annex 3. If constant, the Vr's location will be on a straight line. If not, the location of the Vr will be on an angular area.
Path distance factor		D or S		Distance factor to describe path length between the Wt and the Vr. This factor will be multiplied by R_{max}^{wt} to obtain the coverage area. Therefore, the trialled distance between Wt and Vr will be R_{max}^{wt}*Path factor. E.g. if user enters a distribution 0…1, then the distance will be between 0 and R_{max}^{wt}. If the path factor is constant, the Vr will be located on a circle around the Wt.
Coverage radius calculation mode				Three different modes of calculation of the coverage radius R_{max}^{wt} of a given system, see Annex 6. The user should check the consistency of this parameter with the sensitivity, so that if a receiver is placed at given distance such as the maximum coverage radius, the received power is higher than the Sensitivity for a reasonable percentage of time (availability).

Table 6: Victim Link/Wt-Vr/Uncorrelated case

3.4.2 Tab sheet Victim link/Wt-Vr path/Propagation Model

The second tab sheet is used for selection of the propagation model. Choose a propagation model by consulting section 2.4.3 and Annex 7.

3.5 Window Interfering Link/General

Description	Symbol	Type	Unit	Comments
Name: name of the interfering link				
Description: comments on the link				
Interfering transmitter: choose in the menu a transmitter already defined in the library				Call a transmitter already defined in the Library, otherwise type the inputs directly.
Wanted receiver: choose in the menu a receiver already define in the library				Call a receiver already defined in the Library, otherwise type the inputs directly.
Frequency: Distribution of the frequency of the interfering link		D or S	MHz	Distribution of the centre frequency of the interferer bandwidth.

Table 7: Interfering link/general

3.6 Window Interfering Link/Interfering transmitter

Two tab sheets are available:

- general
- antenna

3.6.1 Tab sheet Interfering link/Interfering transmitter/General

Description	Symbol	Type	Unit	Comments
Name: name of the interfering transceiver				
Description: comments on the transceiver				
Antenna height	h	S or D	m	See Annex 2
Antenna azimuth: Antenna alignment horizontal tolerance	δ^H	D or S	degree	This is the angle between the It main beam and the direction towards Wr. E.g. if antenna azimuth=0, the It and Wr antennas are aligned in horizontal plane, see Annex 2.
Antenna elevation: Antenna alignment vertical tolerance	δ^V	D or S	degree	This is the vertical angle between the It main beam and the aligned direction towards Wr. E.g. if antenna elevation=0, the It and Wr

				antennas are aligned in vertical plane, see Annex 2.
Power: define a distribution of the transmitter power.		D or S	dBm	Interfering transmitter's output power in the emission bandwidth.
Unwanted emission mask: Unwanted signal level (Transmitting mask)	emission_ rel(f)	F(MHz)	dBc/ reference bandw. (MHz)	Define the mask of the transmitter, in the emission bandwidth and out of the emission bandwidth. Negative values in the relative mask should be chosen in a way that the integration over the emission bandwidth results in the total emitted power, see Annex 10. If constant mask, there is no emission outside of the bandwidth.
Unwanted emissions floor: Noise floor signal level	emission_ floor(f)	F(MHz)	dBm/ reference bandw. (MHz)	Define the minimum strength of the unwanted emissions. So the unwanted emissions equal to Max(Pit + Pcontrol + Unwanted emission, Unwanted emissions floor) (See Annex 10)
Emission bandwidth		S	kHz	This band is the reference bandwidth for the transmitting power.
Power control				If Power control is checked, the 3 following parameters have to be defined. This Power control is used to limit the output power of the transmitter, see Annex 12.
Power control/**Power control step size**	Pc^{st_rg}	S	dB	
Power control/ **Min threshold**	$Pc_{threshold\_rg}$	S	dBm/ emission bandw.	If the received power is lower than th threshold, then no power control takes place
Power control/**Dynamic range**	Pc_{dyn_rg}	S	dB	If the received power is higher than Pc_{hold} + Pc_{dyn} then the full power control takes place, i.e. the power is decreased by Pc_{dyn}

Table 8: Interfering link/Interfering transmitter

3.6.2 Tab sheet Interfering link/Interfering transmitter/Antenna

(See Annex 5)

3.7 Window Interfering Link/Wanted receiver

Two tab sheets are available:

- general
- antenna

3.7.1 Tab sheet Interfering link/Wanted receiver/General

Description	Symbol	Type	Unit	Comments
Name: name of the wanted receiver				
Description: comments				
Antenna height	h_{wt}	S or D	m	See Annex 2
Antenna azimuth: Antenna alignment horizontal tolerance	δ^{H}_{wt}	S or D	degree	This is the angle between the Wr main beam and the direction towards It. E.g. if antenna azimuth=0, the Wr and It antennas are aligned in the horizontal plane, see Annex 2.
Antenna elevation: Antenna alignment vertical tolerance	δ^{V}_{wt}	S	degree	This is the vertical angle between the Wr main beam and the aligned direction towards It. E.g. if antenna elevation=0, the Wr and It antennas are strictly aligned in vertical plane, see Annex 2.

Table 9: Interfering Link/Wanted receiver

3.7.2 Tab sheet Interfering link/Wanted receiver/Antenna

(See Annex 5)

3.8 Window Interfering link/It-Wr path

Two tab sheets are available:

- relative location
- propagation model

3.8.1 Tab sheet Interfering link/It-Wr path/Relative location

- Correlation case: position between the receiver and the transceiver is defined using Cartesian coordinates.

Description	Symbol	Type	Unit	Comments
Correlation distance				Checked
Delta X, delta Y	X Y	S	km	Distance between the transmitter and receiver in the interfering link.

Table 10: Interfering Link/It-Wr path/Correlated case

- Uncorrelated case: A coverage radius is calculated. Three different modes are available for calculating the maximum radius $R^{it}_{\max}$ (see Annex 6). The Wanted receiver will be randomly deployed within the area centred on the Interfering transmitter and limited by the maximum radius $R^{it}_{\max}$.

Description	Symbol	Type	Unit	Comments
Correlation distance				Unchecked
Path azimuth		D or S	Degrees	Horizontal angle for the location of the Wr respect to the It, see Annex 3. If constant, the Wr's location will be on a straight line. If not, the location of the Wr will be on an angular area.
Path distance factor		D or S		Distance factor to describe path length between the It and the Wr. This factor will be multiplied by $R_{\max}^{it}$ to obtain the coverage area. Therefore, the trialled distance between It and Wr will be $R_{\max}^{it}$ *Path factor. E.g. if user enters a distribution 0…1, then the distance will be between 0 and $R_{\max}^{it}$. If the path factor is constant, the Wr will be located on a circle around the It.
Coverage radius calculation mode				Three different modes of calculation of the coverage radius are available, as described in Annex 6. However the **noise-limited network option is not available** for this link, due to the fact that the sensitivity of the wanted receiver is not defined. The user should check the consistency of this parameter with the sensitivity, so that if a receiver is placed at given distance such as the maximum coverage radius, the received power is higher than the Sensitivity for a reasonable percentage of time (availability).

Table 11: Interfering link/It-Wr path/Uncorrelated case

3.8.2 Tab sheet Interfering link/It-Wr path/Propagation Model

The second tab sheet is used for selection of the propagation model. Choose a propagation model by consulting section 2.4.3 and Annex 7.

3.9 Window Interfering link/It-Vr path

Two tab sheets are available:

- relative location
- propagation model

3.9.1 Tab sheet Interfering link/It-Vr path/Relative location

- Correlation case: position between two transceivers is defined using Cartesian coordinates: Choose between different correlation modes: It->Vr; It->Wt; Wr->Wt; Wr->Vr.

Description	Symbol	Type	Unit	Comments
Correlation distance				(IT-VR), (IT-WT), (WR-WT) or (WR-VR)
Delta X, delta Y	X Y	S	km	Distance between the two transceivers. The reference depends on the choice of correlation.

Table 12: Interfering Link/It-Vr path/Correlated case

- Uncorrelated case:

A simulation radius is calculated, R_{simu}, see Annex 8. Interfering transmitters will be randomly deployed within the area centred on the Victim receiver and delimited by the simulation radius R_{simu}.If a protection is defined then Interfering transmitters will be randomly deployed within the area centered in the Victim receiver and delimited by the protection distance and the simulation radius R_{simu} .

Description	Symbol	Type	Unit	Comments
Correlation distance				None
Path azimuth		D or S	Degrees	Horizontal angle for the location of the It respect to the Vr, see Annex 3. If constant, the It's location will be on a straight line. If not, the location of the It will be on an angular area.
Path distance factor		D or S		Distance factor to describe path length between the It and Vr. This factor will be multiplied by R_{simu} to obtain the coverage area. Therefore, the trialled distance between It and Vr will be R_{simu} *Path factor. E.g. if user enters a distribution 0…1, then the distance will be between 0 and R_{simu}. **If the path factor is constant, the It will be located on a circle around the Vr which means that the distance between the It and Vr won't change**
Protection distance		S	(km)	Minimum distance between the Victim receiver and the Interfering transmitter
Rayleigh distribution for the closest interferer				The distance between the Victim receiver and the Interfering tansmitter follows a Rayleigh distribution, where the standard deviation is given by $\sigma = \frac{1}{\sqrt{2\pi dens_{active} P_{trans} activity}}$ (see the parameters defined bellow).
Number of active transmitter	n^{active}	S		

Density of active transmitters	$dens_{active}$	S	$1/km^2$	Maximum number of active transceivers per km^2
Probability of transmission	P_{trans}	S		
Activity	activity	F	1/h	Activity as a function of the time of the day
Time	*time*	S	hh	If the activity function (above) is defined by the user, here it should be specified which hour (from the defined range of function) should be considered in a simulation

Table 13: Interfering Link/It-Vr path/Uncorrelated case

3.9.2 Tab sheet Interfering link/It-Vr path/Propagation Model

The second tab sheet is used for selection of the propagation model. Choose a propagation model by consulting section 2.4.3 and Annex 7.

3.10 Simulation control

Simulation control parameters are set by calling "*Scenario/Simulation control*" menu option. The control parameters used there are described in the following table.

Description	Symbol	Type	Unit	Comments
Number of events	N	S		The number of trials: this is the number of different random configurations of WT, VR, IT, WR that the software generates to calculate the iRSS and the dRSS. Then, in the DEE, SEAMCAT calculates distributions based on the arrays of dRSS and iRSS. (0 < N < 500,000) Indication on the current stage of the simulation process is displayed in the status bar of SEAMCAT software.
Termination condition				• **Number of events**: simulation to stop after a certain number of samples. So, the **Significance level for stability estimation,** the **Add number of events** and the **Significant level for distribution identification** are not useful**.** ***Pbl***: No stability evaluation, the user can make a simulation with only 2 events. • **DEE driven**: The software asks the EGE to generate more samples if the number of samples is considered as insufficient to ensure the probability stability. • **Expected duration**: The simulation to stop after certain duration. So, the **Significance level for stability estimation,** the **Add number of events** and the **Significant level for distribution identification** are not useful**.** ***Pbl***: No stability evaluation.

Time left		S	Min	If **Expected duration** was chosen.
Significance level for stability estimation		S		Value used for Chi-squared test. In order to check if the distribution obtained with N-dN samples and the one obtained with N samples respect this comparison threshold. If user increases this value, the stability increases. The maximum number of samples is 2*N. ***Pbl***: SEAMCAT allows values more than 1.
Add number of events	dN	S		Number of trials to add. If DEE detects unacceptable variations in discrete distribution resulted from the EGE and estimated in two successive estimations using N and N+dN sample size, the EGE is instructed to generate another dN of additional samples. This test is repeated until a tolerable variation of the parameters is measured over the pre-defined number of successive tests.
Significant level for distribution identification		S		Value used for the Chi-squared test. In order to check if signal issued by the EGE compared to a known continuous distribution respect this comparison threshold. Use for the interpolation in distributions of the array vectors output by the EGE. ***Pbl***: SEAMCAT allows values more than 1.
Correlation threshold	ε	S		See the Note 1 below. ***Pbl***: This value must be included between 0 and 1 however SEAMCAT allows any positive values.

Table 14: Simulation control parameters

Note 1: Estimating the correlation threshold

The correlation is a measure of dependency between two values:

- means of vectors X and Y: m_X, m_Y
- variances of vectors X and Y.

The correlation factor is calculated by SEAMCAT based on the following expression:

$$\rho = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}(X_i - m_X)(Y_i - m_Y)}{\sigma_X{}^2\sigma_Y{}^2} = \text{E[XY]-E[Y]E[X]/ } \sigma_x\sigma_y$$

4 ICE control parameters

After completing the EGE/DEE simulations, it is possible to proceed with calculation of probability of interference, using the SEAMCAT ICE function. It is launched using the "Simulation/Interference calculation" menu option. ICE control parameters are described below.

Description	Comments
Calculation mode/**Compatibility**: The result is a probability of interference.	Compatibility: Gives the probability of being interfered by the Blocking interference and/or by the Unwanted interference and/or by intermodulation interference.
Calculation mode/**Translations**: the result is a graph. In this case all the following parameters should be independent from frequencies: Receiver blocking response mask, Receiver intermodulation rejection mask, power distribution of interfering transmitter, Unwanted emission floor mask.	Calculation of the probability of interference as a function of the reference parameters: • Power supplied by the It for the unwanted, • Blocking response level of the Vr for the Blocking, • And intermodulation rejection level for the Vr. Useful when there is more than 2 interfering transmitter at f1 and f2, iRSS intermodulation ½ fo=2f2-f1 or 2/1 2f1-f2 and fo must be in the Vr bandwidth. These parameters are varying on user-defined definition domain defined by the number of points where the software has to calculate the probability, see Annex 11.
Signal type	Choose the interference studied: Unwanted and/or Blocking and/or Intermodulation.
Algorithm	Choose the appropriate algorithm.
Algorithm/**Quick**:	• Interfering signals (N) issued by EGE for each of the interfering links (n) involved in the interfering scenario are statistically independent (non correlation). • One of the interfering links have an iRSS which is dominant with respect to all the other interfering signals.
Algorithm/**Complete 1**:	See Annex 11.
Algorithm/**Complete 2**:	See Annex 11.
Samples	Number of samples from the distribution calculated by the DEE, it represents the number of events to calculate the probability. The accuracy of the probability results derives from this parameters..
Interference criterion	Choose between C/I, C/(N+I), (N+I)/N, I/N)
Translation parameters: If translation was chosen	Number of points between the min and max, where the software will calculate the probability.
Calculation control	Delete a result, and see the last results
Result/Compatibility	Probability of interference: 1 - always interfered, 0 - never interfered
Result/Translation	Gives the graph, showing the resulting probability of interference vs. the selected values of translation parameter. The average of the graph depends of the number of points, but the higher the number is, the longer the calculations are.

Table 15: Parameters to calculate the probability of interference

5 Meaning of SEAMCAT error messages

Using SEAMCAT, unclear error messages can pop up without any real definition of the reason why. This section is aimed to explain the meaning of these error messages.

Warning "XXX is not a floating point value"

This error message means that an empty field has been input instead of a number.

Consistency check

This function is performed prior to simulation with the aim of detecting incorrect or questionable input values.

Consistency check is performed by the SEAMCAT at two instances: immediate individual check upon entering certain parameters and global consistency check when starting the simulation.

Constraints for individual scalar parameters such as antenna gains are checked when the user enters a value for entities as antenna, transceiver or link. Example of parameters with associated constraints are listed in Table 16.

Nature of the parameter	Type	Constraint
Antenna horizontal pattern		Angle between 0° and 360°
Antenna vertical pattern		Angle between -90° and 90°

Table 16: Individual constraints for scalar parameters

A global consistency check is performed with scenario parameters when the user starts the simulation. Such control covers:

- check of limits for uniform random parameters such as antenna height, etc.
- consistency between different parameters : C/I, C/N+I, N+I/N, and I/N
- warnings about the questionable use of distributions, e.g. transceiver located on a cell border if the path distance distribution is set to 1 and use of uniform polar distribution for random parameters other than relative location of transceivers.
- verification of assumptions made for algorithms

List of the checked parameters is provided in Table 16 below.

Checked parameters	Constraint / warning	Status
Antenna height distributions	In case of constant or uniform distribution check that definition interval of the distribution density does not include negative values.	Error
Receiver C/I, C/N+I, N+I/N, I/N	Following equations must be verified : Consistency check between interference criteria is to be performed : • Between C/I, C/(N+I), and (I+N)/I only if these 3 parameters are defined.	Warning

	$\frac{N+I}{N} = 10\log\left[1 + \frac{1}{10^{\frac{\frac{C}{I} - \frac{C}{N+I}}{10}} - 1}\right] dB$ • Between I+N/I and I/N if these two parameters are defined. $\frac{N+I}{N} = 10\log\left[1+10^{\frac{I}{10N}}\right] dB$ (see Notes 1 to 4)	
All **random** parameters	If distribution type is uniform discrete, check that Xmax – Xmin is multiple of the step. • Note that this condition is not mandatory to the use of this distribution.	Warning
All **random** parameters **except** Path distance factor distribution	Use of following distribution type is **inappropriate** • Uniform polar (distance)	Warning
All **random** parameters **except** Path azimuth distribution	Use of following distribution type is **inappropriate** : • Uniform (angle)	Warning
Distance factor distributions	Use of following distribution type is **inappropriate** : Constant	Warning
Coherence between Victim Receiver masks (blocking rejection and inter-modulation rejection) and interfering transmitter frequency distribution.	In case of **uniform** or **constant** frequency distribution for the interfering transmitter, check that the definition interval of the distribution is **totally included** : • In the blocking rejection mask In the intermodulation rejection mask	Error
Coherence between Interfering Transmitter masks (Unwanted emission and unwanted emissions floor) and victim receiver frequency distribution.	In case of **uniform** or **constant** frequency distribution for the victim receiver, check that the definition interval of the distribution is **totally included** : • In the unwanted emissions mask if not constant • In the interfering transmitter bandwidth if the unwanted emissions mask is assumed constant. In the intermodulation rejection mask if more than two interfering links are defined.	Error
Use of Closest interfer mode for calculation of the distance between interfering transmitter and victim receiver	• Warn the user that following assessments are made : - Simulation radius = 1 - Distance factor = Rayleigh of standard deviation $\sigma = \frac{1}{\sqrt{2\pi dens_{it}^{active}}}$	

Table 17: Global consistency check parameters

Note 1:

C : represent the desired signal received from the Wanted Transmitter

I: represents the interfering power received by the Victim Receiver

N: represent the power noise produced by electronic components

Note2:

The user defines protection criteria and chooses one of then when conducting the evaluation of the probability of interference (C/I, C/(N+I), (N+I)/N ,I/N). If more than one these parameters are defined by the user, SEAMCAT performs a consistency checking between the interference criteria (see Note 3).

Note 3:

For example, it is possible to calculate the (N+I)/N when the values of C/I and C/(N+I) are known:

If it is assumed that, for example:

C/I=19dB C/(N+I)=16dB

Using the equation:

$$\frac{N+I}{N} = 10\log\left[1 + \frac{1}{10^{\frac{\frac{C}{I} - \frac{C}{N+I}}{10}} - 1}\right] \quad (1)$$

gives:

$$\frac{N+I}{N} = 10\log\left[1 + \frac{1}{10^{0,3} - 1}\right] = 3\text{dB}$$

Therefore, if User provides a value for each of these parameters (C/I, C/(N+I) and (N+I)/N), SEAMCAT uses the equation (1) to check the consistency of these parameters (see Note 4).

Taking into account this value of (I+N)/N and using the equation:

$$\frac{N+I}{N} = 10\log\left[1 + 10^{\frac{I}{10N}}\right] \quad (2)$$

The previous example leads to:

$$\text{I/N (dB)} = 10\log\left[10^{0.3} - 1\right] = 0\text{dB}$$

Therefore, if User provides a value for (N+I)/N and I/N, SEAMCAT uses the equation (2) to check the consistency of these parameters (see Note 4).

So, to complete the above example, the values of 19 dB, 16 dB, 3 dB and 0 for the C/I, C/(N+I), I/N and (N+I)/N parameters respectively would be appropriate and the warning would not appear.

Note 4:

Due to the non-additive formula linking these parameters, tolerance of 0.5 dB is to be used when defining the protection criteria.

Annex 1: To define a distribution or a function

A1.1. Defining a distribution

Description	Comments
Constant	Type a constant value
User defined	Define a distribution i.e. values associated with probability.
Uniform	Define the min and the max values. All the values between them will have the same probability (0,1).
Gaussian	Define a Gaussian distribution with its mean and standard deviation.
Rayleigh	Define a Rayleigh distribution with its min and standard deviation.
Uniform polar distance	Define the max distance. All the points distributed over an circular area defined by max distance have the same probability. This is equivalent to define a uniform density of transmitters. $\sqrt{(0,1)}$
Uniform polar angle	Define the angle max. The values included between -αmax and αmax have the same probability.
User defined distribution	Input area for the user defined distribution. Load and save allow the import/export of user defined values.
Discrete uniform distributions	Define the lower bound Xmin and the Upper bound Xmax of the distribution. The distribution is a discrete distribution between following values : $X_i = X_{\min} + S/2 + (i-1)S$ each value being assigned the same probability $P(X_i) = 1/N$ with $i = 1 \ldots N$ $N = (X_{\max} - X_{\min})/S$ (See Figure A2.1)
User defined (stair)	User-defined (stair) is designed to provide a generic implementation of discrete distributions. These distributions are defined through a discrete set of values *Xi, i = 1…N* and associated probabilities *Pi*. *Pi* are entered in cumulated form *Si*. where $S_i = \sum_{j=1}^{i} P_j$ such distributions will be entered in form of a list of couples *(Xi, Si)*. Entering such a distribution in cumulated form allow to control that the sum of the probabilities is equal to 1.

- Uniform distribution: $U(0,1) = \begin{cases} 1 & \text{if } 0 \le x \le 1 \\ 0 & \text{otherwise} \end{cases}$
- Gaussian distribution: $G(\sigma) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{x^2}{2\sigma^2} \right)$
- Rayleigh distribution: $R(\sigma) = \frac{r}{\sigma^2} \exp\left(-\frac{r^2}{2\sigma^2} \right)$
- Discrete uniform distribution:

This is a special distribution bounded by a lower boundary X_{min} , an upper boundary X_{max} and the step S between the samples x_i . A common example of such a distribution is the discrete frequency distribution having a constant channel spacing.

The corresponding distribution for x_i is then defined by the following equation:

$$x_i = X_{min} + S/2 + (i-1)S$$

where

$i = 1...N$

$$N = (X_{max} - X_{min})/S$$

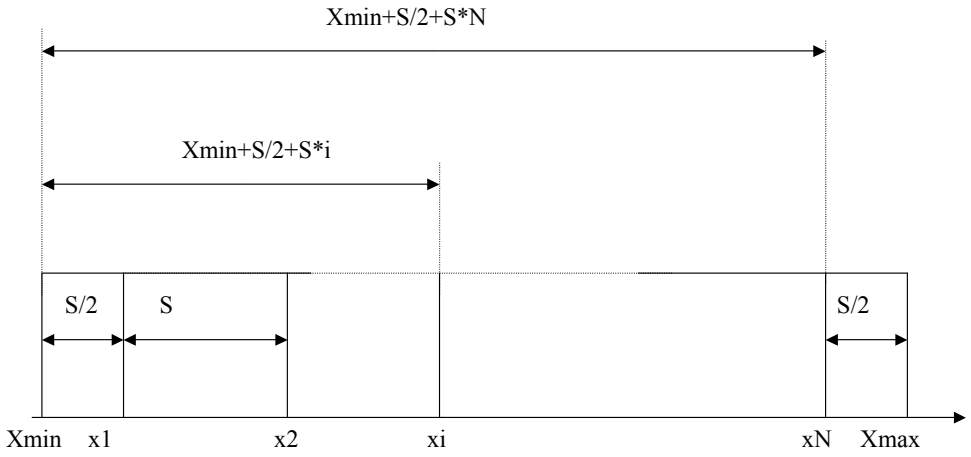


Figure A1.1: Discrete uniform distribution

In the case of a uniform distribution, each value is assigned to the same probability

$P(x_i) = 1/N.$

- Discrete non-uniform distribution:

These distributions are defined through a discrete set of values $Xi,\ i = 1 \ldots N$ and associated probabilities Pi. In order to keep coherence with the continuous distribution and for checking convenience probabilities, Pi will be entered in cumulated form Si, where $S_i = \sum_{j=1}^{i} P_j$, such distributions will be entered in form of a list of couples *(Xi, Si)*.

Entering such a distribution in cumulated form allow to control that the sum of the probabilities is equal to 1

Note: To see the formula of the distribution open the distribution's window and press F1.

A1.2. To define a function

Description	Comments
Constant	Constant value.
User-defined	Input as many values as needed for abscissa and corresponding function response values, paying attention to units shown in the heading of the relevant function definition window. Example of user-defined function was shown e.g. in Fig. 5.

Annex 2: Definition of antenna height, pointing azimuth and elevation

The "*General*" scenario tab sheets for all participating transmitters and receivers in both victim and interfering links have the "Antenna pointing" selection fields, allowing setting:

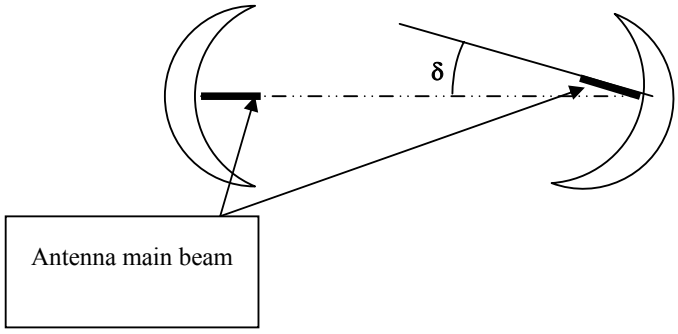
- height of subject antenna;
- antenna pointing azimuth;
- antenna pointing elevation.

The height of antenna should correspond to its definition in the selected propagation model for that link (e.g. it might be the height above ground, effective height or height above local clutter).

The antenna pointing azimuth effectively mean antenna de-pointing, i.e. angle between the direction of main beam and the direction towards the calculated position of corresponding pair transceiver of the victim or interfering link. E.g. for Vr antenna the pointing azimuth value should describe the angle between direction of Vr's antenna main beam and the path to Wt.

This parameter may be used either to add certain variable parameter to the final link budget due to random de-pointing of antennas (e.g. in mobile environment), or to show deliberate de-pointing of antenna (e.g. choosing a particular gain point on the antenna directivity pattern).

The antenna pointing elevation means the same pre-programmed de-pointing as the above descried azimuth parameter, but in vertical plane. The meaning of these parameters is illustrated in Fig. A2.1 below.



δ - Antenna (de-) pointing azimuth angle or elevation angle

– · · – · · - Direction towards corresponding pair transceiver in a link

The plane of the figure is horizontal for the azimuth angle and vertical plane for the elevation angle.

Figure A2.1: Definition of the antenna pointing azimuth/elevation angle

It should be noted that these antenna pointing azimuth and elevation angles have impact only on the ultimate antenna gain applied in calculation of the link budget, but not on the mutual physical positioning of transceivers. The latter is impacted by the "Path azimuth angle" parameter, described in Annex 3.

Unless some intentional meaning of antenna de-pointing is foreseen in simulation scenario, it is recommended to set always the antenna pointing and elevation angle parameters to const=0, meaning that the main beam of the antenna is directed towards the corresponding pair transceiver in a link.

Annex 3: Definition of path azimuth

Conventions for azimuth angle definitions

For the path azimuths in the Wt->Vr and It->Wr links, the reference point is a **transmitter** and the angle is from the positive direction of Ox axis to the path towards a corresponding receiver in a link.

For the path azimuth used in describing relative Vr->It positioning, the reference point is at **Vr** and the angle is between the positive direction of Ox axis and the path towards the It.

These principles of defining azimuth angles are illustrated in the following picture.

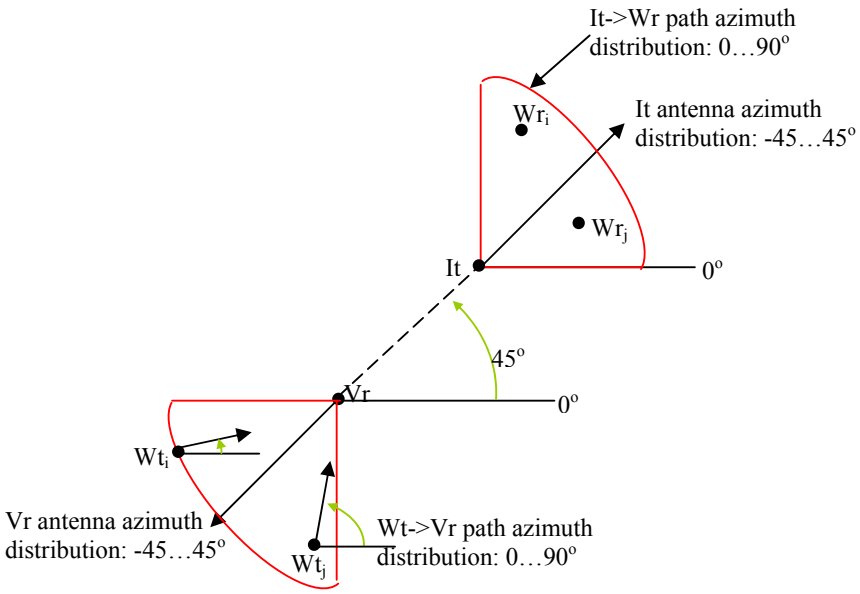


Figure A3.1: Describing the path azimuth angles

Entering azimuth angles

The geometric positioning of victim and interfering systems in Figure A3.1 may be programmed within the SEAMCAT interference scenario in the following way:

- It->Vr path: relative location mode: none, path azimuth - constant at 45°, appropriate distance parameters;
- It->Wr path: path azimuth: 0…90°;
- Wt->Vr path: path azimuth: 0…90°;
- Vr antenna pointing: either 0° or e.g. uniform azimuth: -45…45°;
- It antenna pointing: either 0° or e.g. uniform azimuth: -45…45°.

Please consult the relevant Tables in section 3 of this manual for further clarification on input of angular parameters for particular transceivers/links.

Annex 4: Definition of receiver selectivity and blocking attenuation

This annex aims to explain the process of calculation of the receiver attenuation (denoted as *avr*) when using various modes of defining receiver selectivity and blocking, available in SEAMCAT. The value of *avr* is then applied by SEAMCAT to the received interfering signal to obtain the value of $iRSS_{blocking}$ (ref. section 2.1 of Annex 9).

A4.1. Basic concept

The receiver is capturing some unwanted signal because of its filter being not ideal.

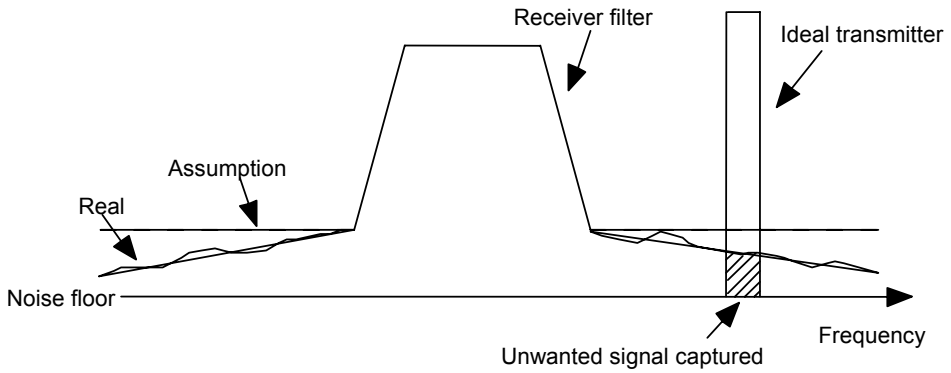


Figure A4.1: Receiver filtering of unwanted signal

The term "Blocking" is used in SEAMCAT to describe a Victim receiver's selectivity function, as a measure of the receiver capability to filter adjacent unwanted signal, so that this unwanted signal does not cause degradation of the received modulated useful signal beyond a specified limit.

Two main methods, covering three user-selectable modes, exist in SEAMCAT to define this blocking function:

- Filter attenuation (*User-defined* mode) – where receiver attenuation is expressed directly as Net Filter Discrimination;

- Blocking response (*Protection ratio* mode and *Sensitivity* mode) – where receiver attenuation is calculated by SEAMCAT from a certain fundamental relationships between signals, as described in section A4.3 below.

In all cases SEAMCAT perceives receiver blocking as a receiver mask, which is generally a function of frequency separation between interfering and desired signals $\Delta f=(f_{It} - f_{Vr})$, however user may also specify a constant value of blocking across the whole frequency range.

When calculating the $iRSS_{blocking}$, SEAMCAT will apply the obtained receiver attenuation value *avr* to the full power of adjacent channel interfering signal and will consider the resulting product (interfering signal at receiver input less blocking attenuation) as the victim receiver's in-channel noise floor increase.

A4.2. User-defined mode

In this case, the receiver attenuation is input directly as Net Filter Discrimination (see Figure A4.2), with absolute values in dB. Therefore SEAMCAT will take the receiver attenuation $a_{vr}(\Delta f)$ values directly from the function (might be also constant value) entered by the user.

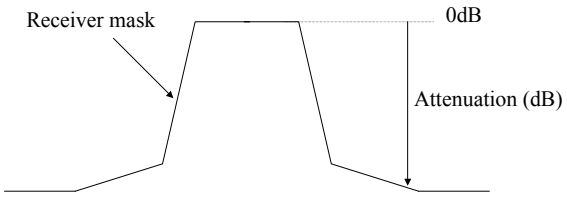


Figure A4.2: Receiver attenuation in SEAMCAT "User-defined" mode

Note that positive values should be entered to correspond to appropriate reduction of interfering signal.

A4.3. Protection ratio and Sensitivity modes

In these two modes SEAMCAT will calculate the receiver attenuation from indirect input parameters:

- required protection ratio (*Protection ratio* mode), or
- maximum tolerable interference signal levels (*Sensitivity* mode).

In both these modes, calculation of applicable receiver attenuation $a_{vr}(\Delta f)$ will be based on certain fundamental relationships between signals, as derived from the blocking level measurements described in ETSI EN 300 113 (section 9), with reference to blocking definition in ITU-R SM.332-4.

A.4.3.1. Blocking level measurements

To calculate the receiver attenuation in blocking response modes, the fundamental relationships between receiver sensitivity, wanted signal, interfering signal and thermal noise need to be established, based on the principle of measuring blocking as a level of adjacent interfering signal which results in reduction of output power from modulated useful signal by a certain limit.

This limit of acceptable wanted signal degradation is assumed to be 3 dB, based on suggestion in ITU-R SM.332-4 and the blocking measurement procedure described in ETSI EN 300 113. The latter procedure is briefly summarised as follows (see Fig. A4.3):

- The wanted signal (Generator A) is switched on, tuned at receiver frequency and its level is adjusted to the level of maximum useable sensitivity of the receiver, which corresponds to BER=10^{-2} at the receiver output. The level of wanted signal is then further increased by 3 dB;

- The unwanted signal is added by switching on Generator B, with given frequency shift from receiver frequency, and its output level is first increased until a BER=10^{-1} or worse is obtained; then decreased again until the BER=10^{-2} is re-attained at the receiver output;

- The corresponding level of unwanted signal is noted. The "blocking" ratio is then expressed as ratio, in dB, of the level of unwanted signal to the level of wanted signal;

- Test is repeated for other frequency shifts Δf.

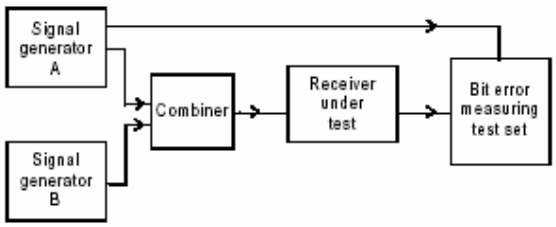


Figure A4.3: Blocking measurement arrangement (from ETSI EN 300 113)

A4.3.2. Receiver attenuation as element of blocking response

Based on the definition and measurement procedure of blocking, it is possible to obtain the receiver attenuation parameter $a_{vr}(\Delta f)$ from the following fundamental relationships between wanted and unwanted signals, receiver sensitivity and noise, as observed when blocking event is triggered (see Fig. A4.4):

- *Noise Floor* + S/N = *Receiver Sensitivity*
- *Noise Floor* + S/N + 3 dB = *Wanted Signal Level* $|_{\text{Measurement setup}}$
- *Wanted Signal Level* $|_{\text{Measurement setup}}$ + *Protection ratio*(Δf) = *Interfering Signal Level* $|_{\text{Blocking triggered}}$
- *Interfering Signal Level – Receiver attenuation* $a_{vr}(\Delta f)$ = *Noise Floor*

Note that the definition of a_{vr} in the final relationship is based on the assumption that the interfering signal is reduced by the receiver filter to the level of thermal noise, thus causing increase of overall receiver in-band noise by 3 dB, i.e. when:

$$N_{Total}=N_{Thermal} + I = | \text{ when } I=N_{Thermal} | = N_{Thermal} + N_{Thermal} = 2 \cdot N_{Thermal} = N_{Thermal} \text{ [dBm]} + 3 \text{ dB}$$

This corresponds to pre-setting of wanted signal level by 3 dB above receiver sensitivity during blocking measurements.

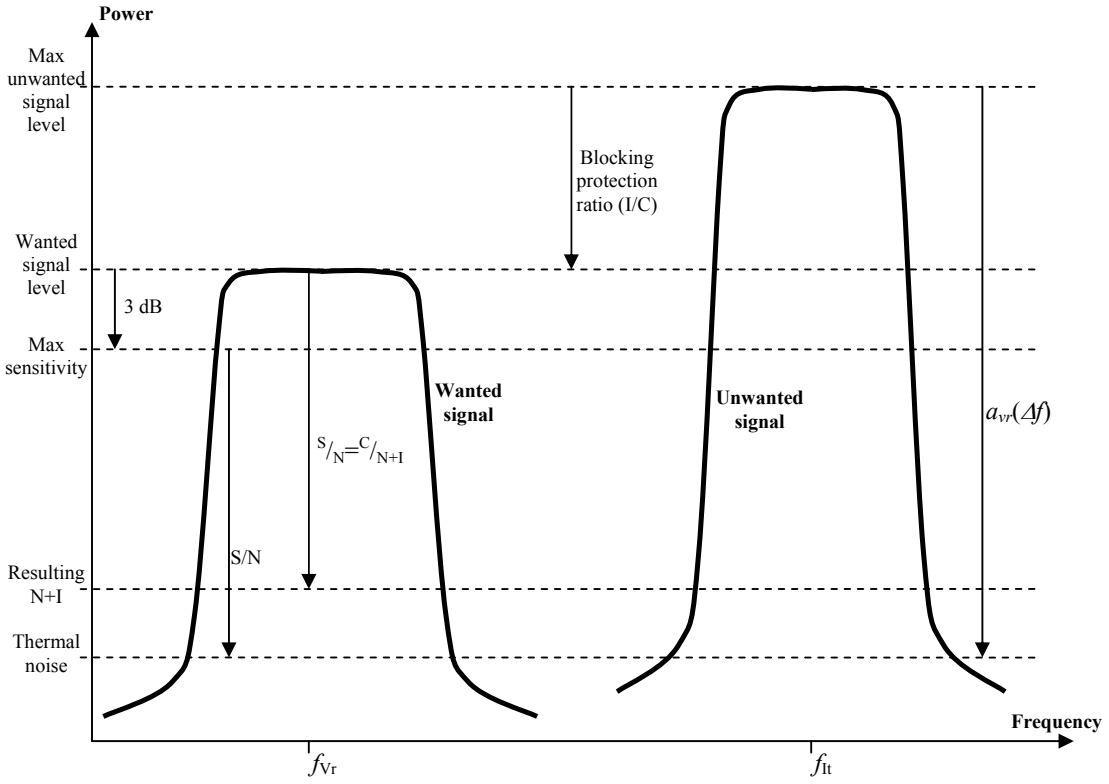


Figure A4.4: Relationship between signal levels when blocking occurs

It is also important to note that SEAMCAT assumes that the fundamental receiver protection criteria of signal-to-noise ratio is to be represented in calculations of receiver blocking by the C/(N+I) parameter defined by the user in simulation scenario for Victim receiver.

A4.3.3. SEAMCAT calculation of receiver attenuation in the Protection ratio mode

In this calculation mode the function entered by the user represents the Protection ratio (see Fig. A4.4), i.e. the ratio of maximum acceptable level of interfering signal to the wanted signal level, at a given frequency separation.

In this case SEAMCAT calculates the receiver attenuation $a_{vr}(\Delta f)$ to be applied to the interfering signal by using the following expression, derived from the relationships explained in section A4.3.2:

- $a_{vr}(\Delta f) = block_{Protection\ Ratio}(\Delta f)$ [dB] + $C/(N+I)$ [dB] + 3 dB (**NOTE**)

Where:

$\Delta f=(f_{It} - f_{Vr})$

A4.3.4. SEAMCAT calculation of receiver attenuation in the Sensitivity mode

In this calculation mode the function entered by a user represents the absolute power level (in dBm) of maximum interfering signal, which might be tolerated by the receiver at a given frequency separation.

In this case SEAMCAT calculates the receiver attenuation $a_{vr}(\Delta f)$ to be applied to the interfering signal by using the following expression, derived from the relationship explained in section A4.3.2:

- $a_{vr}(\Delta f) = block_{Max\ Interf\ Signal}(\Delta f)$ [dBm] – $sens_{vr}$ [dBm] + $C/(N+I)$ [dB] (**NOTE**)

Where:

$\Delta f=(f_{It} - f_{Vr})$

$sens_{vr}$ - sensitivity of the VR (dBm) as defined in the simulation scenario.

NOTE: The current version of SEAMCAT (ver 2.1) takes the value of C/(N+I) directly as entered by the user in Victim receiver description in simulation scenario. Other interference criteria (C/I, (N+I)/N and I/N) do not have any influence on the calculations of receiver blocking attenuation.

Annex 5: Definition of antenna parameters

Description	Symbol	Type	Unit	Comments
Name: name of the Antenna				
Description: comments on the antenna				
Antenna peak gain	g_{max}	S	dBi	Peak antenna gain.
Horizontal patterns: Horizontal normalized antenna pattern	$g^{V}(\theta)$	F	dB/degree	Input positive values for the angle, so between 0^{O} and 360^{O}. For the gain, only input negative values relative to the Antenna peak gain.
Vertical patterns: Vertical normalized antenna pattern	$g^{H}(\varphi)$	F	dB/degree	Input angle values between -90^{O} and 90^{O}. For the gain, only input negative values relative to the Antenna peak gain.
Spherical patterns: Spherical normalized antenna pattern	$g^{S}(\phi)$			Input spherical angle (φ) and negative antenna gain value relative to the Antenna peak gain: $cos\ \phi = \cos(\theta)*\cos(\varphi)$

Annex 6: Defining coverage radius

Coverage radius parameter is used to describe the operational area of the victim and/or interference systems, within which the location of subject transceivers is possible. SEAMCAT allows three modes for defining the coverage radius.

A6.1. User-defined coverage radius

Description	Symbol	Type	Unit	Comments
Coverage radius	R_{max}	S	km	Input a coverage radius, and fix it with a path loss constant or make little variation around this radius. Useful to give a fixed value for the coverage radius.

A6.2. Noise-limited network

Description	Symbol	Type	Unit	Comments
Propagation model				Choose between pre-defined models (Hata, Spherical diffraction, Free space, ITU-R P.1546, SE 24 model)
Reference antenna height (receiver):	h^0	S	m	The height used for coverage radius calculations. If a distribution is used to define the real height, the coverage radius would be different in each trial, here the value may be fixed.
Reference antenna height (transceiver):	h^0	S	m	The height used for coverage radius calculations.
Reference frequency	f_{vr}	S	MHz	
Reference power	P_{wt}	S	dBm	
Minimum distance			km	
Maximum distance			km	
Availability			%	
Fading standard deviation			dB	
Reference percentage of time			%	

Assuming that the received power is equal to the sensitivity of the victim receiver, then the radius $R_{\max}$ can be determined for the wanted radio path by the following equation according to ERC Report 68 (this feature is available only for pre-defined propagation models and not for user-defined propagation models).

$$F_{median}(f_{vr},h_{vr},h_{wt},R_{\max},env)+F_{slowfading}(X\%)=P_{wt}+g_{wt}+g_{vr}-sens_{vr}$$

where the path loss is defined by a median loss plus an additional term representing the distribution

$$p_{loss} = F_{median} + F_{slowfading}(X\%)$$

The distribution of the of the path loss p_{loss} can be expressed in a general way by the following equation:

$$Q(\mu + a, R_{\max}) = y$$

where Q is the cumulative distribution for $R_{\max}$ and the resulting mean path loss μ and an additional path loss a due to availability or coverage y . The availability y of the system is linked to the coverage loss through the simple relation $y = 1 - x$. Assuming that slow fading can be approximated by log-normal distribution, i.e. median $\approx$ mean, the relation $a = b\sigma$ can be introduced where b stands for a multiple of the well known standard deviation σ . A few examples for illustration: At a 95 % coverage, b results in 1.96, for 99 % in 2.58, for 99.9 % in 3.29, or $b = 1$ 68 % coverage, for $b = 2$ for 95.5 %. The exact values can be easily determined by using the inverse Gaussian function.

Then the equation:

$$v(R_{\max}) = P_{wt} + g_{wt} + g_{vr} - sens_{vr} - F_{median}(f_{vr}, h_{vr}, h_{wt}, R_{\max}, env) - b\sigma$$

The determination of the zero of function v, is made through a recursive method such as regula-falsi used in logarithmic scale which should yield a better precision. The solution of such a method provides:

$$\tilde{R}_{\max} = R_{\max 0} - \frac{R_{\max 0} - R_{\max 1}}{v(R_{\max 0}) - v(R_{\max 1})} v(R_{\max 0})$$

Note that faster convergence can be obtained by applying the distance in logarithmic scale, i.e. the variable R has to be replaced by $\log(R)$.

Note that in this case, formulas given for $F_{median}(f_{vr}, h_{vr}, h_{wt}, R_{\max}, env) + F_{slowfading}(X\%) = P_{wt} + g_{wt} + g_{vr} - sens_{vr}$ have to be inverted.

Note 1: Inverse of the normalised Gaussian cumulative distribution is implemented through a piecewise approximation.

Note 2: Ro to be set to 1 m (0.001 km)

Note 3: If after running the simulation it appears that the resulting coverage radius is equal or very close to the minimum distance or the maximum distance used in calculation of coverage radius, it is likely that there is a mistake in the values provided by the user. This can be solved by reducing the minimum distance or increasing the minimum distance used in calculation, so that the algorithm may find the corresponding coverage radius.

When setting the Rmin, Rmax values, please observe the validity range as appropriate for the selected propagation model, see Table 1, section 2.4.3. Otherwise SEAMCAT will produce the error message when starting a simulation.

A6.3. Traffic-limited network

Description	Symbol	Type	Unit	Comments
Density			1/km^2	
Number of channels				
Number of users per channel				
Frequency cluster				

The coverage radius $R_{\max}^{it}$ (Interfering link) or R_{max}^{wt} (Victim link) is determined from the following equation:

$$\pi \times dens_{\max} \times \left(R_{\max}^{it}\right)^2 = \frac{n_{channels}^{it} \times n_{usersperchannel}^{it}}{cluster_{frequency}^{it}}$$

hence:

$$R_{\max}^{it} = \sqrt{\frac{n_{channels} \times n_{usersperchannel}}{\pi \times dens_{\max} \times cluster_{frequency}}}$$

Annex 7: SEAMCAT propagation models

A7.1. Extended Hata and Extended Hata (SRD) models

- **Input parameters**

Description	Symbol	Type	Unit	Comments
Variation				Variation in path loss takes into account the uncertainty of building design, furniture, room size, etc. This is a **standard deviation** which refers to the mean of the Median path loss.
Median path loss				Depending of the distance, the environment, the frequency and the height of the antenna. This is a **mean.**
General environment				Environment of the propagation: urban, rural, suburban
Local environment(Vr)				Environment of the receiver antenna: outdoor, indoor
Local environment(Wt)				Environment of the transmitter antenna: outdoor, indoor
Propagation environment				Environment of the propagation: Below roof, Above roof (used for standard deviation calculations) ONLY USED IF VARIATION OPTION IS CHECKED
Wall loss(indoor - indoor)		S	dB	
Wall loss std dev (indoor - indoor)		S	dB	
Wall loss(indoor - outdoor)		S	dB	
Wall loss std dev (indoor - outdoor)		S	dB	
Loss between adjacent floor		S	dB	
Empirical parameters:	b			
Size of the room (droom)	droom	S	m	
Height of each floor	hfloor	S	m	

- **Calculation algorithm**

The Extended Hata model implemented in SEAMCAT calculates propagation loss between transmitter and receiver as:

$$f_{propage}(f, h_1, h_2, d, env) = L + T(G(\sigma))$$

where:

- f: frequency (MHz)

- *h1* : transmitter antenna height, m, above ground
- *h2* : receiver antenna height, m, above ground
- *d* : distance between transmitter and receiver, km
- env : general environment

Symbols:

L = median propagation loss (dB)

$H_m = \min(h_1, h_2)$

$H_b = \max(h_1, h_2)$

Median path loss L:

Median path loss L depending on the distance

Dist. Range	Env.	Frequency Range	Median Loss
d < 0,04 km			$L=32.4+20\log(f)+10\log\left[d^2+\frac{(H_b-H_m)^2}{10^6}\right]$
$d > 0{,}1Km$	Urban	30 MHz <f ≤ 150 MHz	$L=69.6+26.2\log(150)-20\log(150/f)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})][\log(d)]^{\alpha}-a(H_m)-b(H_b)$
		150 MHz <f ≤ 1500 MHz	$L=69.6+26.2\log(f)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})][\log(d)]^{\alpha}-a(H_m)-b(H_b)$
		1500 MHz <f ≤ 2000 MHz	$L=46.3+33.9\log(f)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})][\log(d)]^{\alpha}-a(H_m)-b(H_b)$
		2000 MHz < f ≤ 3000 MHz	$L=46.3+33.9\log(f)+10\log(f/2000)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})][\log(d)]^{\alpha}-a(H_m)-b(H_b)$
	suburban		$L = L(\text{urban}) -2\cdot\left\{\log\left[\left(\min\left\{\max\{150;f\};2000\right\}\right)/28\right]\right\}^2 - 5.4$
	open area		$L = L(\text{urban}) - 4.78\cdot\left\{\log\left[\min\left\{\max\{150;f\};2000\right\}\right]\right\}^2 + 18.33\cdot\log\left[\min\left\{\max\{150;f\};2000\right\}\right] - 40.94$
$0{,}04km < d < 0{,}1km$			$L=L(0.04)+\frac{[\log(d)-\log(0.04)]}{[\log(0.1)-\log(0.04)]}\times[L(0.1)-L(0.04)]$

Where:

$$a(H_m) = (1.1\log(f) - 0.7)\cdot\min\{10; H_m\} - (1.56\log(f) - 0.8) + \max\{0; 20\log(H_m/10)\}$$

$$b(H_b) = \min\{0; 20\log(H_b/30)\}$$

$$\alpha = \begin{cases} 1 & d \le 20 \text{ km} \\ 1 + (0.14 + 1.87x10^{-4}xf + 1.07x10^{-3}H_b)(\log\frac{d}{20})^{0.8} & 20 \text{ km} < d < 100 \text{ km} \end{cases}$$

When L is below the free space attenuation for the same distance, the free space attenuation should be used instead.

Variation in path loss

The variation in path loss is achieved by applying the log-normal distribution (slow-fading). The relative standard deviation is given by the following equations:

Dist. Range	Propag. Mode	Standard Deviation
$d \le 0.04km$		$\sigma = 3.5$
$0.04km<d\le0.1km$	above roof	$\sigma=3.5+\frac{(12-3.5)}{(0.1-0.04)}\times(d-0.04)$
	below roof	$\sigma=3.5+\frac{(17-3.5)}{(0.1-0.04)}\times(d-0.04)$
$0.1km < d \le 0.2km$	above roof	$\sigma = 12$
	below roof	$\sigma = 17$
$0.2km < d \le 0.6k\,m$	above roof	$\sigma=12+\frac{(9-12)}{(0.6-0.2)}(d-0.2)$
	below roof	$\sigma=17+\frac{(9-17)}{(0.6-0.2)}(d-0.2)$
$0.6km < d$		$\sigma = 9$

Indoor-outdoor propagation

Use of the modified Hata model for indoor-outdoor propagation introduces the following additional terms

Median loss

$$L^{hata}_{indoor-outdor} = L^{hata}_{outoor-outdor} + L_{we}$$

where : L_{we} is the attenuation due to external walls

Variation in path loss

Uncertainty on materials and relative location in the building increases the standard deviation of the log-normal distribution :

$$\sigma^{hata}_{indoor-outdor} = \sqrt{(\sigma^{hata}_{outoor-outdor})^2 + (\sigma_{add})^2}$$

Indoor-indoor propagation

Use of the modified Hata model for indoor-indoor propagation introduces following adjustments according to the relative location of the transceivers.

Same-building condition

The first step is to estimate whether the transmitter and the receiver are located in the same building. This is done trough a statistic trial. Let us denote *P* the probability that the transceiver and the receiver are located in the same building. *P* is calculated according to the following scheme:

Dist. Range	Same Building Probability
$d \le 0.02km$	$P=1$
$0.02km < d \le 0.05km$	$P = \frac{(0.05-d)}{0.03}$
$0.05km < d$	$P=0$

Transmitter and Receiver in different buildings

When transceiver and receiver are located in different buildings, the calculation mode is similar to the indoor-outdoor propagation mode but with doubled additional values.

Median path loss

$$L^{hata}_{indoor-indoor} = L^{hata}_{outdoor-outdoor} + 2 \times L_{we}$$

where : L_{we} is the attenuation due to external walls

Variation in path loss

$$\sigma^{hata}_{indoor-indoor} = \sqrt{(\sigma^{hata}_{outoor-outdor})^2 + (2\sigma_{add})^2}$$

Transceiver and Receiver in same building

In this latter case a specific propagation model is used:

$$f_{propag}(f, h_1, h_2, d, env) = L + T(G(\sigma))$$

Median Loss

The corresponding median loss is given by the following formula :

$$L(indoor-indoor) = -27.6 + 20\log(d) + 20.\log(f) + fix(\frac{d}{d_{room}}).L_{wi} + k_f\left[\frac{k_f+2}{k_f+1} - b\right].L_f$$

where $k_f = fix(\frac{|h_2 - h_1|}{h_{floor}})$

and where :

L_{wi} : loss of wall (default 5dB)

L_f : loss between adjacent floor (defult 18.3 db)

b : empirical parameter (default 0.46)

d_{room} : size of the room (default 4m)

h_{floor} : height of each floor (default 3m)

Variation in path loss

Variation in path loss is modelled as an additional log-normal distribution, in order to take into account the uncertainty of building design, furniture of the rooms, etc. Typically it is set to 10 dB.

Extended Hata (SRD) - SE24 developed propagation model

This model is a modified version of the SE21 Hata model used by the SE24 study group for study of short range devices. The only difference lies in the expression of the antenna gain factor *b* which is now similar to that of antenna gain factor *a* :

*b = min(0, 20 * log10(Hb/30));*

to be replaced by :

*b = (1.1 * log10(f) - 0.7) * min(10, Hb) - (1.56 * log10(f) - 0.8) + max(0, 20 * log10(Hb / 10));*

A7.2. Spherical diffraction propagation model

- **Input parameters**

Description	Symbol	Type	Unit	Comments
Variation				Variation in path loss takes into account the uncertainty of building design, furniture, room size, etc. Empirical
Median path loss				Depending of the distance, the environment, the frequency and the height of the antenna. It is the free space attenuation.
General environment				Environment of the propagation: urban, rural, suburban
Local environment(Vr)				Environment of the receiver antenna: outdoor, indoor
Local environment(Wt)				Environment of the transmitter antenna: outdoor, indoor
Wall loss(indoor - indoor)		S	dB	
Wall loss std dev (indoor - indoor)		S	dB	
Wall loss(indoor - outdoor)		S	dB	
Wall loss std dev (indoor - outdoor)		S	dB	
Loss between adjacent floor		S	dB	
Empirical parameters:	b			
Size of the room	droom	S	m	
Height of each floor	hfloor	S	m	
Water concentration		S	g/m^2	
Earth surface admittance				
Index gradient				
Refraction layer prob				

- **Calculation algorithm**

According to ITU-R Rec. P.452-5 the median loss between transceiver and receiver is given by the following equation:

$$L_{bd}(p) = 92.5 + 20\log f + 20\log d + L_d(p) + A_g$$

where:

$L_{bd}(p)$ is the basic loss in dB as function of the time percentage p in %

f is the frequency in GHz

d is the distance in km

$L_d(p)$ is the diffraction loss in dB as function of the time percentage p in %

A_g is the attenuation due to atmospheric gas and water in dB

Attenuation due to atmosphere

Attenuation due to atmosphere is given by

$$A_g = \left[\gamma_O(f) + \gamma_w(\rho, f)\right] d$$

where:

$\gamma_O(f)$ linear attenuation due to dry air (oxygen) in dB/km

$\gamma_w(\rho, f)$ linear attenuation in dB/km due to water as function of the water concentration ρ in g/m³, *default value: 3 g/m³*

Both terms can be approximated by the following equations according to ITU-R Rec. P.676-1:

- Attenuation due to water :

$$\gamma_w(\rho, f) = \left[0.050 + 0.0021\rho + \frac{3.6}{(f-22.2)^2 + 8.5} + \frac{10.6}{(f-183.3)^2 + 9} + \frac{8.9}{(f-325.4)^2 + 26.3}\right] f^2 \rho\, 10^{-4}$$

for f < 350 GHz

- Attenuation due to oxygen :

$$\gamma_O(f) = \left[7.19 \cdot 10^{-3} + \frac{6.09}{f^2 + 0.227} + \frac{4.81}{(f-57)^2 + 1.50}\right] f^2\, 10^{-3} \qquad f \leq 57 \text{ GHz}$$

$$\gamma_O(f) = 10.5 + 1.5\,(f - 57) \qquad 57 < f \leq 60 \text{ GHz}$$

$$\gamma_O(f) = 15 - 1.2(f - 60) \qquad 60 < f \leq 63 \text{ GHz}$$

$$\gamma_O(f) = \left[3.79 \cdot 10^{-7}\ f + \frac{0.265}{(f-63)^2 + 1.59} + \frac{0.028}{(f-118)^2 + 1.47}\right] (f + 198)^2\, 10^{-3} \quad \text{for} \quad f > 63 \text{ GHz}$$

Note: For simplification a linear interpolation between 57 and 63 GHz is used. The maximum is 15 dB/km for 60 GHz.

Attenuation due to diffraction

According to ITU-R Rec. P.526-2, the diffraction loss $L_d(p)$ can be derived by the received field strength E referred to the free space E_0 :

$$-L_d(p) = 20\log\frac{E}{E_0} = F(X) + G(Y_1) + G(Y_2)$$

where:

X is the normalized radio path between transmitter and receiver

Y_1 is the normalized antenna height of the transmitter

Y_2 is the normalized antenna height of the receiver

$$X = 2.2\beta\, f^{\frac{1}{3}}\, a_e^{\frac{-2}{3}}\, d$$

$$Y = 9.6\cdot 10^{-3}\beta\, f^{\frac{2}{3}}\, a_e^{\frac{-1}{3}}\, h_i$$

where:

β is a parameter derived from the earth admittance factor K : β=1 for f >20MHz.

f is the frequency in MHz

a_e is the equivalent earth radius in km (definition see below)

d is the distance in km

h_i is the antenna height above ground in m with i=1 or 2 for the transmitter or receiver, respectively

The distance-dependent term $F(X)$ is given by the semi-empirical formula:

$$F(X) = 11 + 10\log(X) - 17.6X$$

The antenna height gain $G(Y)$ is given by the formula set:

$G(Y) = 17.6(Y-1.1)^{\frac{1}{2}} - 5\log(Y-1.1) - 8$ for Y >2

$G(Y) = 20\log(Y + 0.1Y^3)$ for $10K < Y < 2$

$G(Y) = 2 + 20\log K + 9\log(Y/K)\left[\log(Y/K) + 1\right]$ for $K/10 < Y < 10K$

$G(Y) = 2 + 20\log K$ for $Y < K/10$

where:

K is the normalized earth surface admittance factor (see ITU-R Rec. P.526), default value: 10^{-5}

Note : All frequencies used attenuation due to diffraction have the unit MHz in contrast to the attenuation due to atmosphere where GHz is applied.

Equivalent Earth radius

The equivalent Earth radius a_e is considered to be dependent on the time percentage p according to :

$$a_e(p) = 6375\, k(p)$$

with the Earth radius factor $k(p)$ expressed as:

$$k(p) = k_{50} + (5 - k_{50})\frac{(1.7 - \log p)}{(1.7 - \log \beta_0)} \qquad \text{for } p < 50\%$$

$$k(p) = k_{50} \qquad \text{for } p > 50\%$$

and $$k_{50} = \frac{157}{157 - \Delta N}$$

where:

ΔN is the mean gradient of the radio refraction profile over a 1 km layer of the atmosphere from the surface. The *default value* is *40 unit/km* for Europe (standard atmosphere). This yields $k_{50} \approx 4/3$ and a_e = 8500 km.

Note : The mean gradient is positive.

β_0 is the existence probability (in %) of the super-refractive layer ($\Delta N >$ 100 unit/km) in the low atmosphere. *Default value: 1 % for Europe*.

Note : The probabilities p and β_0 are denoted in %, i.e. a range of variety: 0...100 %.

Note : In current version of SEAMCAT, p is set to *50%*, i.e. the median with respect to time is computed. Later versions may allow to choose a certain time percentage.

Range of application

The following restrictions of the aforementioned spherical diffraction model are to be considered:

- When used for outdoor-outdoor environment the model presents no variations even if the "variations" checkbox is checked. On the contrary for indoor-outdoor or indoor-indoor configurations, checking or unchecking the variations checkbox adds suppresses the variable component of the corresponding corrections.
- The frequency range should be larger than 3 GHz, with caution lower frequencies may be used but not below 300 MHz due to the surface admittance and polarisation effects.
- The model was developed for open (rural) area. Therefore, the additional attenuation due to obstacles like buildings found in suburban or urban environment is not included.
- The loss due to rain is not covered.
- This model is applicable only for terrestrial radio paths.

Indoor-outdoor propagation

Use of the SD model for indoor-outdoor propagation introduces the following additional terms

Median loss

Median loss is increased by the attenuation due to external walls :

$$L^{sd}_{indoor-outdoor} = L^{sd}_{outdoor-outdoor} + L_{we}$$

Variation in path loss

Variation in path loss is already taken into account in the SD model, through the calculation of the equivalent earth radius. Thus additional variation due to uncertainty concerning materials and relative location of the transceiver and receiver is reflected by an additional lognormal distribution trial using the above defined σ_{add}.

$$f^{SD}_{propag/indoor-outdoor} = f^{SD}_{propag/outdoor-outdoor} + T(G(\sigma_{add}))$$

Indoor-indoor propagation

Use of the Spherical Diffraction model for indoor-indoor propagation introduces different additional terms regard to the relative location of the transceiver and receiver.

Same-building condition

The Same-Building condition is determined in the same way as for the Modified Hata model (cf. 2.10.1.4.1).

Transceiver and Receiver in different buildings

When transceiver and receiver are located in different buildings, the calculation mode is similar to the indoor-outdoor propagation mode but with doubled additional values for both median path loss and variation path loss.

Median path loss

Median path loss is increased by the attenuation due to external walls L_{we}.

$$L^{SD}_{indoor-indoor} = L^{SD}_{outoor-outdoor} + 2 \times L_{we}$$

Variation in path loss

$$f^{SD}_{propag/indoor-indoor} = f^{SD}_{propag/outdoor-outdoor} + T(G(\sqrt{2}\sigma_{add}))$$

Transceiver and Receiver in same building

The calculation is the same as for the Modified Hata Model. Refer to 2.10.1.4.3.

A7.3. ITU-R Recommendation P.1546 propagation model

- **Input parameters**

Description	Symbol	Type	Unit	Comments
General environment				Environment of the propagation: urban, rural, suburban
Local environment(Vr)				Environment of the receiver antenna: outdoor, indoor
Local environment(Wt)				Environment of the transmitter antenna: outdoor, indoor
Transmitter system (Analog /Digital)				
Transmitter system Bandwidth	Bt	S	MHz	

- **<u>Calculation algorithm</u>**

This propagation model is described in Recommendation ITU-R P.1546, which was developed based on the prior model in Recommendation ITU-R P.370. Recommendation proposes a propagation model for point-to-area prediction of field strength for the broadcasting, land mobile, maritime mobile and certain fixed services (e.g. those employing point-to-multipoint systems) in the frequency range 30 to 3000 MHz and for the distance range 1 km to 1000 km. The model provided in Recommendation ITU-R P.1546 should be used in the frequency range (30 to 3 000 MHz) and the same distance range (1 km to 1 000 km).

Parameters of this propagation model are listed below:

Path dependant parameters (constant during a simulation for a given path) are :

- Time percentage: pt (%)
- Transmitter system : analog/digital
- Transmitter bandwidth : B_t
- Global environment : rural, suburban, urban

Variable parameters (which vary for each event of a simulation) :

- Effective height of transmitter antenna (see the Rec. P.1546 for definition): h_t (m)
- Receiver antenna height (above ground, see height of local clutter in section (6) below): h_r (m)
- Frequency f (MHz)
- Distance d (km)

For calculation of the path loss according to Recommendation ITU-R P.1546 the following procedure is followed:

1) Check range of application of the propagation model regarding time percentage, frequency, distance, and antenna height:

- Time percentage : $1\% < pt < 50\ \%$

The SEAMCAT version 2.1 does not display warning if the time percentage parameter is set by the User beyond 50%!

- Frequency : $30\ \text{MHz} < f < 3\,000\ \text{MHz}$
- Distance : $0.001\ \text{km} < d < 1000\ \text{km}$

- Transmitter antenna height : 0 m < h_t < 3000 m
- Receiver antenna height : 1 m < h_r < 3000 m

2) Determination of lower and higher nominal percentages pt_{inf} and pt_{sup}:

If t < 10 then pt_{inf} = 1 % and pt_{sup} = 10 % else pt_{inf} = 10 % and pt_{sup} = 50 %

3) Determination of the lower and higher nominal frequencies :

If f < 600 MHz then f_{inf} = 100 MHz and f_{sup} = 600 MHz else f_{inf} = 600 MHz and f_{sup} = 2000 MHz

4) If $h_t \geq 10$ m: calculate field strength $E(f= f, d, h_t, h_r, t)$ 4):

4.1) Calculation of the four following field strengths:

- $E(f= f_{inf}, d, h_t, h_r, pt_{inf})$
- $E(f= f_{sup}, d, h_t, h_r, pt_{inf})$
- $E(f= f_{inf}, d, h_t, h_r, pt_{sup})$
- $E(f= f_{sup}, d, h_t, h_r, pt_{sup})$

according to the procedure described in steps 4.1.1. to 4.1.4.

4.1.1) Calculate the dimensionless parameter k, function of the required transmitter height, h_t:

$$k = \frac{\log\left[\frac{h_t}{9.375}\right]}{\log(2)}$$

4.1.2) Determine from the following table the set of parameters a_0 to a_3, b_0 to b_7, c_0 to c_6 and d_0 to d_1 to be used according to nominal values of frequencies and time percentages:

Frequency	**100 MHz**			**600 MHz**			**2 000 MHz**		
***pt* %**	**50**	**10**	**1**	**50**	**10**	**1**	**50**	**10**	**1**
a_0	0.0814	0.0814	0.0776	0.0946	0.0913	0.0870	0.0946	0.0941	0.0918
a_1	0.761	0.761	0.726	0.8849	0.8539	0.8141	0.8849	0.8805	0.8584
a_2	–30.444	–30.444	–29.028	–35.399	–34.160	–32.567	–35.399	–35.222	–34.337
a_3	90.226	90.226	90.226	92.778	92.778	92.778	94.493	94.493	94.493
b_0	33.6238	40.4554	45.577	51.6386	35.3453	36.8836	30.0051	25.0641	31.3878
b_1	10.8917	12.8206	14.6752	10.9877	15.7595	13.8843	15.4202	22.1011	15.6683
b_2	2.3311	2.2048	2.2333	2.2113	2.2252	2.3469	2.2978	2.3183	2.3941
b_3	0.4427	0.4761	0.5439	0.5384	0.5285	0.5246	0.4971	0.5636	0.5633
b_4	1.256E-7	7.788E-7	1.050E-6	4.323^{E}-6	1.704^{E}-7	5.169^{E}-7	1.677E-7	3.126E-8	1.439E-7
b_5	1.775	1.68	1.65	1.52	1.76	1.69	1.762	1.86	1.77
b_6	49.39	41.78	38.02	49.52	49.06	46.5	55.21	54.39	49.18
b_7	103.01	94.3	91.77	97.28	98.93	101.59	101.89	101.39	100.39
c_0	5.4419	5.4877	4.7697	6.4701	5.8636	4.7453	6.9657	6.5809	6.0398

c_1	3.7364	2.4673	2.7487	2.9820	3.0122	2.9581	3.6532	3.547	2.5951
c_2	1.9457	1.7566	1.6797	1.7604	1.7335	1.9286	1.7658	1.7750	1.9153
c_3	1.845	1.9104	1.8793	1.7508	1.7452	1.7378	1.6268	1.7321	1.6542
c_4	415.91	510.08	343.24	198.33	216.91	247.68	114.39	219.54	186.67
c_5	0.1128	0.1622	0.2642	0.1432	0.1690	0.1842	0.1309	0.1704	0.1019
c_6	2.3538	2.1963	1.9549	2.2690	2.1985	2.0873	2.3286	2.1977	2.3954
d_0	10	5.5	3	5	5	8	8	8	8
d_1	–1	1	2	1.2	1.2	0	0	0	0

4.1.3) Calculate the unblended to maximum value field strength, E_u, at the distance, d, and transmitting height, h_t, as follows:

$$E_u = p_b \cdot \log\left[\frac{10^{\frac{E1+E2}{p_b}}}{10^{\frac{E1}{p_b}} + 10^{\frac{E2}{p_b}}}\right]$$

where: $p_b = d_0 + d_1 \cdot \sqrt{k}$

and: $E1 = \left(a_0 \cdot k^2 + a_1 \cdot k + a_2\right) \cdot \log(d) + 0.1995 \cdot k^2 + 1.8671 \cdot k + a_3$

and: $E2 = E_{ref} + E_{off}$

where:

$$E_{ref} = b_0\left[\exp\left[-b_4 \cdot 10^{\xi}\right] - 1\right] + b_1 \cdot \exp\left[-\left(\frac{\log(d) - b_2}{b_3}\right)^2\right] - b_6 \cdot \log(d) + b_7$$

where: $\xi = \log(d)^{b_5}$

and:

$$E_{off} = \frac{c_0}{2} \cdot k \cdot \left[1 - \tanh\left[c_1 \cdot \left[\log(d) - c_2 - \frac{{c_3}^k}{c_4}\right]\right]\right] + c_5 \cdot k^{c_6}$$

4.1.4) Calculate the blended to the free space value of field strength, E_b, at the distance, d, and transmitting height, h_t, as follows:

$$E_b = p_{bb} \cdot \log\left[\frac{10^{\frac{E_u+E_{fs}}{p_{bb}}}}{10^{\frac{E_u}{p_{bb}}} + 10^{\frac{E_{fs}}{p_{bb}}}}\right]$$

where:

E_{fs} is the free-space field strength

E_{fs} = 106.9 – 20 log (d) dB(μV/m)

p_{bb} is a blend coefficient set to value 8.

4.2) Calculation of the field strength *E(f, d, h_t, h_r, pt_{inf})* using log-linear interpolation in frequency range:

$$E = E_{inf} + (E_{sup} - E_{inf}) \log(f/f_{inf})/\log(f_{sup}/f_{inf}) \quad [dB(\mu V/m)]$$

where:

E_{inf}: $E(f= f_{inf}, d, h_t, h_r, pt_{inf})$

E_{sup}: $E(f= f_{sup}, d, h_t, h_r, pt_{inf})$

4.3) Dual calculation for the field strength *E(f, d, h_t, h_r, pt_{sup})* using log-linear interpolation in frequency range:

$$E = E_{inf} + (E_{sup} - E_{inf}) \log(f/f_{inf})/\log(f_{sup}/f_{inf}) \quad [dB(\mu V/m)]$$

where:

E_{inf}: $E(f= f_{inf}, d, h_t, h_r, pt_{sup})$

E_{sup}: $E(f= f_{sup}, d, h_t, h_r, pt_{sup})$

4.4) Calculation of the field strength *E(f, d, h_t, h_r,* pt*)* using log-linear interpolation formula in time percentage range :

$$E = E_{sup} (Q_{inf} - Q_t)/(Q_{inf} - Q_{sup}) + E_{inf}(Q_t - Q_{sup})/(Q_{inf} - Q_{sup}) \quad [dB(\mu V/m)]$$

Where: (Q_i (x) being the inverse complementary cumulative normal distribution function):

$Q_t = Q_i (pt/100)$

$Q_{inf} = Q_i (pt_{inf}/100)$

$Q_{sup} = Q_I (pt_{sup}/100)$

E_{inf} = E(f, d, h_t, h_r, pt_{inf})

E_{sup} = E(f, d, h_t, h_r, pt_{sup})

5) For a transmitting/base antenna height h_t less than 10 m, determine the field strength for the required height and distance using following method

The procedure for extrapolating field strength at a required distance d km for values of h_t in the range 0 m to 10 m is based on smooth-Earth horizon distances in km written as $d_H(h) = 4.1\sqrt{h}$, where h is the required value of transmitting/base antenna height h_t in metres.

For $d < d_H(h_t)$ the field strength is given by the 10 m height curve at its horizon distance, plus ΔE, where ΔE is the difference in field strengths on the 10 m height curve at distances d and the h_t horizon distance.

For $d \geq d_H(h_t)$ the field strength is given by the 10 m height curve at distance Δd beyond its horizon distance, where Δd is the difference between d and the h_t horizon distance.

This may be expressed in the following formulae where $E_{10}(d)$ is the field strength in dB(μV/m) calculated for transmitter antenna 10 m and for a distance d (km) according to the procedure described in step 4:

$$E = E_{10}(d_H(10)) + E_{10}(d) - E_{10}(d_H(h_t)) \quad dB(\mu V/m) \quad d < d_H(h_t)$$

$$= E_{10}(d_H(10) + d - d_H(h_t)) \quad dB(\mu V/m) \quad d \geq d_H(h_t)$$

If in the latter equation $d_H(10) + d - d_H(h_t)$ exceeds 1 000 km, even though $d \leq 1\,000$ km, E_{10} may be found from linear extrapolation for log(distance) of the curve, given by:

$$E_{10} = E_{inf} + (E_{sup} - E_{inf}) \log (d/D_{inf})/\log (D_{sup}/D_{inf}) \quad \text{dB}(\mu\text{V/m})$$

where:

D_{inf}: penultimate tabulation distance (km)

D_{sup}: final tabulation distance (km)

E_{inf}: field strength at penultimate tabulation distance (dB(μV/m))

E_{sup}: field strength at final tabulation distance (dBμV/m))

Note: this recommendation is not valid for distances greater than 1 000 km. This method should be used only for extrapolating for $h_t < 10$ m.

6) If the receiving antenna height h_r is not equal to the height of representative clutter at its location (denoted *R)*, correct the field strength as follows:

The field-strength values given by the land curves and associated tabulations in this recommendation are for a reference receiving antenna at a height, R (m), representative of the height of the ground cover surrounding the receiving/mobile antenna, subject to a minimum height value of 10 m.

The SEAMCAT always assumes the height of local clutter R , depending on the propagation environment set in the model selection window:

Selected environment	Assumed height of local clutter, m
Rural	10
Sub-urban	10
Urban	20

If the receiving antenna height, h_r (m), is different from the assumed R value, as shown in the above table, a correction shall be added to the field strength taken from the curve.

Where the receiving antenna is adjacent to land account should first be taken of the elevation angle of the arriving ray by calculating a modified representative clutter height R' (m), given by:

$$R' = R \quad \text{(m)} \qquad \text{for } h_t \leq 6.5d + R \qquad (1)$$

$$= (1\,000\, d\, R - 15\, h_t)/(1\,000\, d - 15) \quad \text{(m) for } h_t > 6.5d + R \qquad (2)$$

where h_t is in metres and distance d is in km.

The value of R' must be limited if necessary such that it is not less than 1 m.

When the receiving antenna is in an **urban** environment the correction is then given by:

$$\text{Correction} = (6.03\, h_r/R') - J(\nu) \quad \text{dB} \quad \text{for } h_r < R$$

$$= K_{hr} \log (h_r/R') \quad \text{dB} \quad \text{for } h_r \geq R$$

where $J(\nu)$ is given by :

$$J(v) = \left[6.9 + 20 \log\left(\sqrt{(v-0.1)^2 + 1} + v - 0.1 \right) \right]$$

where:

ν	=	$K_{nu} \sqrt{} (h_{dif} \theta_{clut})$
h_{dif}	=	$R' - h_r$ (m)
θ_{clut}	=	arctan (h_{dif}/15) (degree)
K_{hr}	=	3.2 + 6.2 log (f)
K_{nu}	=	0.0108 $\sqrt{} f$
f	=	frequency (MHz)

Where the receiving antenna is adjacent to land in a rural environment the correction is given by the above equation (2) for all values of h_r.

If the required distance is equal to or greater than $\boldsymbol{d_{10}}$, then again the correction for the required value of h_2 should be calculated using above equation (2) with R' set to 10 m.

If the required distance is less than $\boldsymbol{d_{10}}$, then the correction to be added to the field strength E should be calculated using:

Correction	= 0.0	dB	$d \le d\ (h_r)$
	= (C_{10}) log(d/d_{hr})/log(d_{10}/d_{hr})	dB	$d_{hr} < d < d_{10}$

where:

C_{10}: correction for the required value of h_r at distance d_{10} using equation (2) with R' set to 10 m,

d_{10}: distance at which the path just has 0.6 Fresnel clearance for h_r = 10 m calculated as $D_{06}(f, h_t, 10)$ as given in note 2

d_{hr}: distance at which the path just has 0.6 Fresnel clearance for the required value of h_r calculated as $D_{06}(f, h_t, h_r)$ as given in note 2

This recommendation is not valid for receiving antenna heights, h_r, less than 1 m.

7) Add a log-normal term $G(\sigma_L)$ corresponding to the variability in the percentage of locations :

Values of standard deviation for digital systems having a bandwidth less than 1 MHz and for analogue systems are given as a function of frequency by:

$$\sigma_L = K + 1.6 \log(f) \quad \text{dB}$$

where :

K = 2.1 - for mobile systems in urban locations;

3.8 - for mobile systems in suburban locations or amongst rolling hills;

5.1 - for analogue broadcasting systems.

For digital systems having a bandwidth of 1 MHz or greater, a standard deviation of 5.5 dB should be used at all frequencies.

8) If necessary, limit the resulting field strength to the maximum value calculated as follows:

The field strength must not exceed a maximum value E_{max} given by:

$E_{Max} = E_{fs}$ dB(μV/m) for land paths

where E_{fs} is the free space field strength for 1 kW e.r.p. given by:

$$E_{fs} = 106.9 - 20 \log (d) \quad [\text{dB}(\mu\text{V/m})]$$

9) Convert field strength to path loss using following formula:

$L_b = 77.2 - E_{\cdot} \; 20 \log f$ [dB]

where:

L_b: basic transmission loss (dB)

E: field strength in dB(μV/m) measured with a transmitting power of 1 W e.i.r.p.

f: frequency (MHz).

Note 1: The following approximation to the inverse complementary cumulative normal distribution function, $Qi(x)$, is valid for $0.01 \le x \le 0.99$:

$Q_i(x) = T(x) - \xi(x)$ if $x \le 0.5$

$Q_i(x) = -\{T(1-x) - \xi(1-x)\}$ if $x > 0.5$

where:

$$T(x) = \sqrt{[-2 \ \ln(x)]}$$

$$\xi(x) = \frac{[(C_2 \cdot T(x) + C_1) \cdot T(x)] + C_0}{[(D_3 \cdot T(x) + D_2) \cdot T(x) + D_1] \cdot T(x) + 1}$$

$C_0 = 2.515517$
$C_1 = 0.802853$
$C_2 = 0.010328$
$D_1 = 1.432788$
$D_2 = 0.189269$
D3 = 0.001308

Note 2: the path length which just achieves a clearance of 0.6 of the first Fresnel zone over a smooth curved Earth, for a given frequency and antenna heights h_t and h_r, is given approximately by:

$$D_{06} = \frac{D_f \ D_h}{D_f + D_h} \text{ km}$$

where:

D_f: frequency-dependent term
= $0.0000389 \ f \ h_1 \ h_2$ km
D_h: asymptotic term defined by horizon distances
= $4.1(\sqrt{h_t} + \sqrt{h_r})$ km
f: frequency (MHz)
h_t, h_r: antenna heights above smooth Earth (m)

In the above equations, the value of h_t must be limited, if necessary, such that it is not less than zero. Moreover, the resulting values of D_{06} must be limited, if necessary, such that it is not less than 0.001 km.

Note 3: the case h_t is less than zero described in the recommendation is not handled.

Note 4: no correction due to terrain clearance angle is implemented.

A7.4. Free space propagation model

For free space model the path loss is defined by:

$$L=32.5+10\log\left(\left(\frac{(h_{tx}-h_{rx})}{1000}\right)^2+d^2\right)+20\log f$$

A7.5. User defined propagation model

- **Input parameters**

Description	Symbol	Type	Unit	Comments
General environment				Environment of the propagation: urban, rural, suburban
Local environment(Vr)				Environment of the receiver antenna: outdoor, indoor
Local environment(Wt)				Environment of the transmitter antenna: outdoor, indoor
Propagation environment				Environment of the propagation: Below roof, Above roof
Comments				Placeholder for the script of the model

- **Implementation**

The user-defined propagation model is intended to allow the user to create its own propagation models through a script describing the pass loss calculation. This script consists of a sequence of formulas conforming to a well-defined syntax and may be edited by means of standard text editor available on the current environment such as NotePad.

Following script illustrates the application of user-defined model for simulation of free-space attenuation taking into account the difference in antenna height:

```
L1 = 32.44;

L2 = 20 * log10(freq());

L3 = 10 * log10(dist()*dist() + (hrx()-htx()) * (hrx()-htx())/1000/1000);

L = L1 + L2 + L3;

eval L;
```

For detailed description of script language, syntax, functions, etc, please see the in-built SEAMCAT Help file.

Annex 8: Calculation of interference simulation radius

This function is aimed for the calculation of the radius R_{simu} of the area where the interfering transmitters are spread (centered on the victim receiver).

Input:

- Interfering transmitter
  - n^{active}: number of active interferers in the simulation (n^{active} should be sufficiently large so that the $(n+1)^{th}$ interferer would bring a negligible additional interfering power).
  - $dens_{it}^{active}$: density of active transmitters
  - P_{it}: probability of transmission
  - $activity_{it}(time)$: temporal activity variation as a function of the time of the day (hh/mm/ss)
  - *time*: Time of the day

Output:

- Radius of interferer area R_{simu}

Processing:

R_{simu} is defined as:

$$R_{simu} = \sqrt{\frac{n^{active}}{\pi \times dens_{it}^{active}}}$$

where $dens_{it}^{active}$ is the density of active transmitters:

$$dens_{it}^{active} = dens_{it} \times p_{it}^{tx} \times activity_{it}(time)$$

If a minimum protection distance (d_0) between the victim receiver and interfering transmitter is introduced then R_{simu} results in:

$$R_{simu} = \sqrt{\frac{n^{active}}{\pi \ dens_{it}^{active}} + d_0^2}$$

Annex 9: Calculation of desired (*dRSS*) and interfering (*iRSS*) signals

In this annex, *T* represents a trial from a given distribution (Annex 1). These distributions can be constant, user-defined, uniform *U* (0 , 1), Gaussian *G* (σ), Rayleigh*R* (σ) uniform polar distance sqrt(*U* (0 , 1)) and uniform polar angle.

If the user wishes to understand and check SEAMCAT, the easiest way is to use the Free space propagation model, which makes manual calculation simple (Annex 11).

***1. dRSS* calculation**

1.1 Basic algorithm for calculation of dRSS

$$dRSS_{calc} = p_{wt\ \text{supplied}} + g_{wt->vr} - pl_{wt->vr}(f_{vr}) + g_{vr->wt}$$

If the received signal can not exceed a given value, i.e. depending on the power control implemented in the victim system) :

$$dRSS = \min(dRSS_{calc}\ ,\ dRSS_{\max})$$

The following variables are used in the previous formula:

$p_{\ wt\ supplied} = T(P_{\ wt\ supplied})$ power supplied to the wanted transmitter antenna;

$pl_{\ wt->vr}$ path loss between the wanted transmitter and the victim receiver (propagation loss depending on the propagation model, slow fading and clutter losses taken into account). Depending on whether the criteria of interference will apply to:

- the instantaneous dRSS, the path loss will be different for each trial:

  $pl_{\ wt->vr} = f_{propag}\ (f_{vr},\ h_{vr},\ h_{wt},\ d_{vr->wt},\ env) = L + T(Dv)$

  f_{propag} = propagation model (both median loss and variation selected in propagation model selection tab sheet)

- the mean dRSS, the mean path loss will be assumed (the same for all trials):

  $pl_{\ wt->vr} = f_{median}\ (f_{vr},\ h_{vr},\ h_{wt},\ d_{vr->wt},\ env) = L$

  f_{median} = propagation model (only median loss selected in the model tab sheet)

$f_{vr} = T(f_{vr})$ = The frequency of Vr, it can be set constant or defined by a certain distribution, e.g. the "discrete frequency distribution".

$h_{\ vr} = T\ (H_{\ vr})$ victim receiver antenna height, e.g.:

$$h_{vr} = T(U(h_{\ vr\ min},\ h_{\ vr\ max})) = h_{\ vr\ min} + (h_{\ vr\ max} - h_{\ vr\ min})\ T(U\ (0,1))$$

$h_{\ wt} = T\ (H_{\ wt})$ wanted transmitter antenna height, e.g.:

$$h_{\ wt} = T\ (U\ (h_{\ wt\ min},\ h_{\ wt\ max})) = h_{\ wt\ min} + (h_{\ wt\ \ max} - h_{\ wt\ min})\ T(U(0,1))$$

env environment type, as implemented in the selected model (urban, rural, outdoor, indoor….)

$d_{\ wt\ ->\ vr} = T(R^{wt}_{max})$ – distance between the Vr and the Wt, it is calculated through multiplying a trialled distance distribution factor by the coverage radius $d_{wt\to vr} = T(D_{wt\to vr}) \times R^{wt}_{\max}$, e.g.:

$d_{wt \rightarrow vr} = R_{max}^{wt} * \sqrt{T(U(0,1))}$

R_{max}^{wt} - radius of the Wt coverage.

Three different choices for calculation of R_{max}^{wt} are possible (see Annex 6):

- User-defined radius R_{max}^{wt};
- Radius defined by a Noise limited network;
- Radius defined by a Traffic limited network.

The azimuth $\alpha_{vr \rightarrow wt}$ of the Wt-Vr path (see Annex 3) is calculated trough a trial according to the defined distribution:

$$\alpha_{wt \rightarrow vr} = T\left(A_{wt \rightarrow vr}\right)$$

Then the relative positioning of the transceivers of the victim link in is calculated in Cartesian coordinates. Relative positioning is always expressed relatively to the transmitter.

$$\Delta X_{wt/vr} = d_{vr \rightarrow wt} \cos(\alpha_{vr \rightarrow wt})$$
$$\Delta Y_{wt/vr} = d_{vr \rightarrow wt} \sin(\alpha_{vr \rightarrow wt})$$

Consequently, assuming that one of the two transceivers is fixed (through logical connection to other transceivers/links in the interference scenario) it is then possible to use the relative positioning to determine the absolute location of the second transceiver.

$g_{wt \rightarrow vr} = f(g_{wt\,\max}, pattern_{wt}) = g_{wt\,\max} \times pattern_{wt}(\theta_{wt \rightarrow vr}, \varphi_{wt \rightarrow vr}, f_{vr})$ - Wt antenna gain in the direction of Vr, with $g_{wt\,\max}$ - maximum antenna gain of the Wt.

$pattern_{wt}$ = Wt's normalised antenna pattern within operating bandwidth.

$(\theta_{wt \rightarrow vr}, \varphi_{wt \rightarrow vr})$ = azimuth and elevation (the latter when spherical antenna pattern is defined) angles from the Wt antenna towards the Vr antenna.

$g_{vr \rightarrow wt} = f(g_{vr\,\max}, pattern_{vr}) = g_{vr\,\max} * pattern_{vr}(\theta_{wt \rightarrow vr} + \pi, -\varphi_{wt \rightarrow vr, f_{vr}})$ – Vr antenna gain towards Wt.

1.2. Case of fixed positions for Vr and Wt (correlated distance)

In this case the positions of Vr and Wt are fixed. The user defines the distance between the transmitter and receiver in the Victim link by defining the difference of location in term of Cartesian coordinates (Delta X and Delta Y). In this case the *dRSS* is calculated using the main algorithm described in section 1.1 above, but appropriate changes are made to the calculation of mutual positioning of Vr and Wt, because of it being fixed

1.3. Case of user-defined dRSS

The constant value or distribution of *dRSS* may be deifned by the user in the Victim Link scenario window. In this case the SEAMCAT EGE skips algorithms for calculation of dRSS and proceeds directly to calculation of *iRSS*.

Skipping the *dRSS* calculation also means that the SEAMCAT will have not have the positions of transceivers in a victim link trialled/calculated. If these positions are important for further analysis (e.g. when using directional antennas), the *dRSS* calculation should not be skipped.

2. *iRSS* calculations

For the *iRSS* calculation *k* different interfering systems may be considered, each having some *n* active interfering transmitters. The resulting interfering power in the victim receiver is computed as described in the algorithm below. The following considerations are restricted to the case of *k*=1 only for simplification.

2.1. Blocking interfering field strength ($iRSS_{block}$) calculation

$$iRSS_{block} = \sum_{i=1,\ i=n\ interferers} f\left(p_{it\ supplied},\ g_{it\ PC},\ g_{it->vr},\ pl_{it->vr},\ a_{vr},\ g_{vr->it}\right)_i$$

$$iRSS_{block} = 10 \cdot \log\left(\sum_{i=1}^{n} 10^{\frac{iRSS_{block,i}}{10}}\right)$$

Where the *i*-th interferer's signal is given by

$$iRSS_{block,i} = \left(p_{it\ supplied} + g_{it\ PC} + g_{it->vr} - pl_{it->vr} - a_{vr} + g_{vr->it}\right)$$

where for each interferer:

$f_{it} = T(f_{it})$ Interfering link operating frequency.

Note that the trial of the *dRSS* frequency, f_{vr}, occurs only once for each simulation round, i.e. f_{vr} is trialled once, together with the Wt, Vr positions, the Wt transmit power and other distributions pertaining to the victim link. These values associated with the *dRSS* trial round then apply to all *n* trials of *iRSS* (where *n* is the number of interferers).

$p_{it\ supplied} = T(P_{it\ supplied})$ power supplied to the It antenna (before power control).

$g_{it\ PC}$ = power control gain for the It with the power control function, see Annex 12.

$pl_{it->vr}$ = path loss between the interfering transmitter *i* and the victim receiver, e.g.:

$$pl_{it->vr} = f_{propag}(f_{it}, h_{vr}, h_{it}, d_{it->vr}, env) + f_{clutter}(env), \text{ or}$$

$$pl_{it->vr} = f_{median}(f_{it}, h_{vr}, h_{it}, d_{it->vr}, env) + f_{clutter}(env)$$

The choice between f_{median} and f_{propag} would depend on the criteria of interference, and is closely related to the choice made for assessment of *dRSS*, e.g. whether ICE will evaluate: $dRSS_{mean}$ / $iRSS_{mean}$, $dRSS_{propag}$ / $iRSS_{propag}$ or $dRSS_{mean}$ / $iRSS_{propag}$.

$d_{it->vr}$ = distance between the Vr and the It.

Four different ways to define $d_{it->vr}$:

The most common case is when there is no spatial correlation between the elements of the victim system and the elements of the interfering systems.

- Mode None

The User defines directly the simulation radius and a distribution describing the way to spread the interferers around the victim. Then $d_{it->vr}$ is a result of a trial: $d_{it->vr} = R_{simu} * T$

- Mode Uniform density

The User provides the parameters allowing to determine the simulation radius. Then $d_{it->vr}$ is a result of a trial:

$$d_{it->vr} = R_{simu} * \sqrt{T(U(0,1))}$$

R_{simu} = radius of the area where interferers are spread defined by the

R_{simu} is defined as:

$$R_{simu} = \sqrt{\frac{n^{active}}{\pi \times dens_{it}^{active}}}$$

where: $dens_{it}^{active}$ is the density of active transmitters: $dens_{it}^{active} = dens_{it} \times p_{it}^{tx} \times activity_{it}(time)$

n_{active} = number of active interferers considered in the simulation. n_{active} should be sufficiently large so that the n+1 interferer would bring a negligible additional interfering power.

If a minimum protection distance, $d_{it \to vr} \geq d_0$ between the Vr and It is introduced then R_{simu} results in:

$$R_{simu} = \sqrt{\frac{n^{active}}{\pi \ dens_{it}^{active}} + d_0^2}$$

Each trial with $d_{it \to vr} < d_0$ will be rejected and repeated for another trial producing $d_{it \to vr} \geq d_0$.

- Mode Correlated

This case deals with the situation where the victim system and the interfering system are geographically correlated (e.g. co-located or constantly spaced base stations).

This correlation is assumed to be only between one element (Vr or Wt) of the victim system and one element (It or Wr) of the interfering system.

A trial (if the distance is not constant) of the distances and angles between the two correlated elements is made (e.g. $\theta_{wr->vr}$, $d_{wr->vr}$). The knowledge of $\theta_{it->wr}$, $d_{it->wr}$, $\theta_{vr->wt}$, $d_{vr->wt}$ enables to derive the missing coordinates (e.g.$\theta_{it->vr}$, $d_{it->vr}$).

- Mode Closest interferer

The influence of the closest interferer can be estimated by having a distance $d_{it \to vr}$ following a Rayleigh distribution $R(\sigma)$ as defined in Annex 1 and where the parameter σ is related to the density of transmitters

$$\sigma = \frac{1}{\sqrt{2\pi dens_{it}^{active}}}$$

where: $$dens_{it}^{active} = dens_{it} \times p_{it}^{tx} \times activity_{it}(time)$$

$g_{it->vr} = (g_{it\,max}, pattern_{it}) = g_{it\,max} \times pattern_{it}(\theta_{it->vr}, \varphi_{it->vr})$ - It antenna gain towards Vr.

$g_{vr->it} = (g_{vr\,max}, pattern_{vr}) = g_{vr\,max} \times pattern_{vr}(\theta_{it->vr}, \varphi_{it->vr})$ – Vr antenna gain towards It.

$A_{it \to vr}$ - azimuth from Vr towards It (see Annex 3), calculated trough a trial according to the chosen correlation type.

$(\theta_{it\to vr}, \varphi_{it\to vr})$= azimuth and elevation (the latter when spherical antenna pattern is defined) angles from the closest It antenna towards the Vr antenna.

$a_{Vr}(f_{it}, f_{vr})$ - blocking attenuation of the victim receiver.

Three possible ways are considered for calculating the blocking attenuation:

- a_{Vr} is defined by the user
- blocking is given in terms of blocking attenuation or protection ratio:

  For a wanted signal 3 dB above the sensitivity, the attenuation a_{vr} can be derived from the following equation (see Annex 4):

$$a_{vr} = f\left(\frac{C}{N+I}, block_{att}\right) = 3 + \frac{C}{N+I} + block_{att}(f_{it}, f_{vr})$$

- blocking is given in terms of absolute level of blocking.

$$a_{vr} = f\left(\frac{C}{N+I}, block_{abs}\right) = \frac{C}{N+I} + block_{abs}(f_{it}, f_{vr}) - sens_{vr}$$

  Details of the algorithms are given in Annex 4. Two cases are envisaged:

  1) *block* is a mask which is a function of $\Delta_f = (f_{it} - f_{vr})$. It is introduced to enable calculations of interference between systems in adjacent band.

  2) *block* is a fixed value (e.g. 80 dBm). It is used to derive generic limits.

2.2. Unwanted interfering field strength ($iRSS_{unwanted}$) calculation

The used algorithm is similar to that described in section 2.1:

$$iRSS_{unwanted} = f(\text{emission}_{it}, g_{it\,PC}, g_{it->vr}, pl_{it->vr}, g_{vr->it})_i$$

$$iRSS_{unw} = 10\log\left(\sum_{i=1}^{n} 10^{\frac{iRRSSunwanted\_i}{10}}\right)$$

where the *i*-th interferer signal is defined as:

$$iRSS_{unwanted\_,i} = (\text{emission}_{it}(f_{it}, f_{vr}) + g_{it->vr} - pl_{it->vr}(f_{vr}) + g_{vr->it})$$

where, other than parameters described before:

$$emission_{it}(f_{it}, f_{vr}) = \max\{p_{it}^{supplied} + emission\_rel_{it}(f_{it}, f_{vr}) + g_{it}^{PC}, emission\_floor_{it}(f_{it}, f_{vr})\}$$

- $emission\_rel_{it}$ is a relative emission mask which is a function of $\Delta_f = (f_{it} - f_{vr})$, see Annex 10. It is introduced to enable calculations of interference between systems in the same or adjacent bands. The real emission is always greater or equal than the absolute emission floor $emission\_floor_{it}(f_{it}, f_{vr})$.

2.3. Intermodulation interfering field strength ($iRSS_{intermod}$) calculation

Bug warning: When calculating impact of intermodulation, the version 2.1.0 of SEAMCAT produces an $iRSS_{intermod}$ vector with values expressed in relation to the VR's noise floor, as explained below.

However, when the interference calculation is later initiated, ICE assumes that the $iRSS_{intermod}$ values are expressed in absolute (dBm) terms, as it is the case for two other interfering signal vectors (unwanted and blocking). **Therefore, calculation of probability of intermodulation for selected signal type "*Intermodulation*" will produce erroneous results.**

This fault is noted for correction in the next release of SEAMCAT. Meanwhile, it appears that users may apply a temporary "work-around" technique - that is to increase the value of intermodulation attenuation parameter of VR by one third of the receiver's noise floor value. This puts the resulting calculated $iRSS_{intermod}$ values at about their absolute values, therefore the ICE may derive the correct interference probability.

For the computation of the intermodulation products in the victim receiver two different interfering systems are required, i.e. k > 1:

$iRSS_{intermod} = f\left(p_{it,\,k\ \ supplied}, g_{it,k\,PC}, g_{it,k->vr}, pl_{it,k->vr,}\, g_{vr->it,k}, sens_{vr}, intermod \right)$, with k=i,j.

$$iRSS_{intermod} = 10\log\left(\sum_{i=1}^{n} \sum_{\substack{i=1 \\ i \neq j}}^{n} 10^{\frac{iRSS_{intermod,i,j}}{10}} \right)$$

where:

$i_{i,j}\,RSS_{intermod}$ = intermodulation product of third order at the frequency f_0

$i_{i,j}\,RSS_{intermod} = 2*\ i_{i}RSS_{int} + \ i_{j}RSS_{int}\ -3intermod - 3\,sens_{vr}$ –9dB (Note 1)

Note 1: $i_{i,j}\,RSS_{intermod}$ is defined in SEAMCAT as the power of intermodulation product above the noise floor of victim receiver, see Appendix 9 to Annex 2 of ERC Report 68 for detailed description of this definition.

The interferer i transmits at the frequency $f_{it,i} = f_{it}$ and the interferer j at $f_{it,j}$, which defines $\Delta_f = \left(f_{it,j} - f_{it}\right)$ and yields $f_0 = f_{it} - \Delta_f = 2\,f_{it} - f_{it,j}$. Assuming an ideal filter (roll-off factor 0) the intermodulation product has to be considered only for the bandwidth b:

$$f_{vr} - b/2 \le f_0 \le f_{vr} + b/2$$

For all other cases the intermodulation product will be neglected.

Another parameters used in the formula above:

$ikRSS_{int} = p_{it,\,k\ \ supplied}, g_{it,k\,PC}, g_{it,k->vr}, pl_{it,k->vr,}\, g_{vr->it,k}$ - received power in the victim receiver due to interferer $k=i$ at f_{it} or interferer $k=j$ at $f_{it,j}$.

$sens_{vr}$ = sensitivity of victim receiver

$intermod$ = receiver intermodulation rejection for a wanted signal 3 dB above the sensitivity:

- $intermod$ is defined by the user, e.g. typical values are 70 dB for base station equipment and 65 dB for mobile and hand-portable equipment. It is used to derive generic limits.
- intermod(Δf) is defined as a function of Δf referred to f_{vr}.

Annex 10: Calculation of unwanted emissions

This annex aims to explain the calculation of the unwanted emissions.

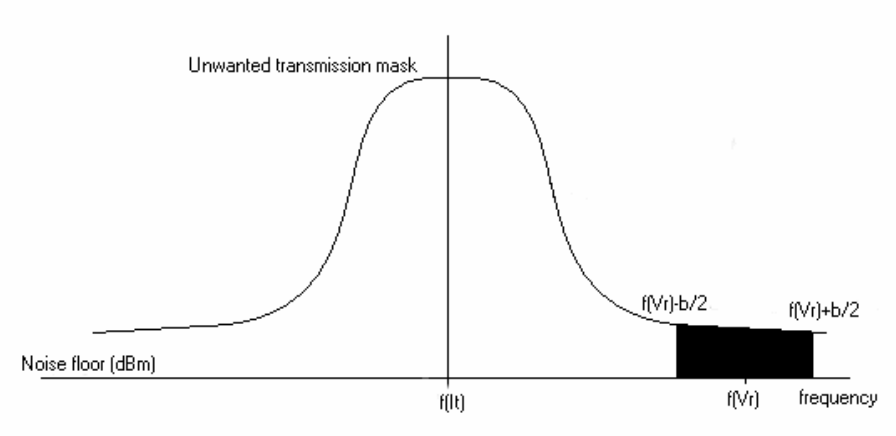


Figure A10.1: Unwanted emissions in the victim receiver band

$emission_{it}(f_{it}, f_{vr}, g_{pc})$ = emission from the interfering transmitter (see figure A10.1).

For the interfering transmitter, an emission mask $emission_{it}$ is defined as a function of $\Delta f = f - f_{it}$ and can be defined as maximum power levels $emission_{it}(\Delta f)$ in reference bandwidth $b_s(\Delta f)$ specified by the user. This mask can also be expressed as the maximum of

- the sum of the supplied interfering power $p_{it}^{supplied}$, a relative emission mask (containing the wanted transmission and all unwanted emissions including the emission floor depending on the power control) and the gain power control
- or the absolute emission floor.

The relative emission mask is described by a triplet (frequency offset (MHz), relative emission level (dBc) and reference bandwidth (MHz)). The emission floor is defined in section 2) of this Annex.

The interfering transmitter power $p_{it}^{supplied}$ (dBm) at f_{it} is used for evaluating the link budget with the wanted receiver (i.e. power control).

1 User-defined mask

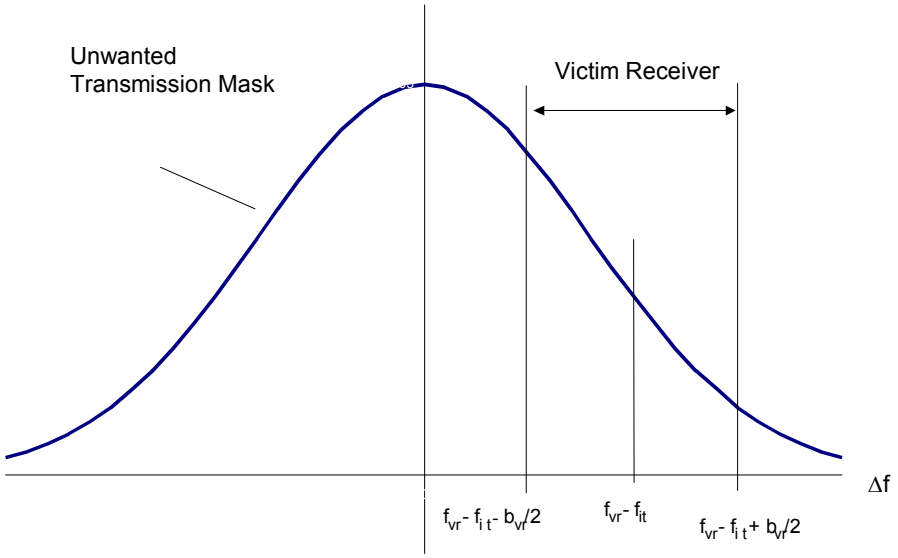


Figure A10.2: Integration of the unwanted emissions in the victim receiver band

The Figure A10.2 shows the principle of the determination of the interfering power. If $f_{it} = f_{vr}$ then the interfering frequencies fall exactly in the receiving band of the victim receiver (co-channel interference).

For simplification within the algorithms the mask function p_{m_it} is normalized to 1 Hz reference bandwidth:

$$p_{n\_it} = p_{m\_it}(\Delta f) - 10\log\frac{b}{1\text{Hz}}$$

The bandwidth b is the bandwidth used for the emission mask. The total received interfering power $emission_{it}$ can easily calculated by integration over the receiver bandwidth from $a = f_{vr} - f_{it} - b_{vr}/2$ to $b = f_{vr} - f_{it} + b_{vr}/2$

$$power_{it} = 10\log\left\{\int_a^b 10\text{^}(p_{n\_it}(\Delta f)/10)\, d\Delta f\right\}$$

with p_{n_it} denoting the normalized mask in dBm/Hz. Using 1 Hz reference bandwidth the integral can be replaced by a summation

$$power_{it} = 10\log\left\{\sum_{i=a}^{b} 10\text{^}(p_{n\_it}(\Delta f_i)/10)\right\}$$

where $power_{it}$ is given in dBm.

NOTE - The interfering power of a radio system having a different bandwidth can be estimated by the aforementioned algorithms. This calculation is only required for the interference due to unwanted emissions but not for blocking and intermodulation.

Note that since version 1.1.5 a user defined mask has always been applied even the mask is flat.

1.1 Implementation in SEAMCAT

In the previous section, the principle is explained. However, this algorithm is very slow in terms of computation time. Therefore the following approach is implemented:

The total interfering power relative to carrier $emission\_rel_{it}$ can be calculated by integration over the receiver bandwidth from $a = f_{vr} - f_{it} - b_{vr}/2$ to $b = f_{vr} - f_{it} + b_{vr}/2$

$$emission\_rel_{it} = 10\log\left\{\int_a^b P_{rel}^{linear}(\Delta f)d\Delta f\right\} = 10\log\left\{\int_a^b 10^{\frac{P_{rel}^{dBc}(\Delta f)}{10}} d\Delta f\right\}$$

With P_{rel}^{dBc} denoting the normalized user-defined mask in dBc/Hz**.**

This mask is expressed as an array of *N*+1 points $(\Delta f_i, P_i)$ and assumed linear between these points.

$$P_{rel}^{dBc}(\Delta f) = P_i + \frac{\Delta f - \Delta f_i}{\Delta f_{i+1} - \Delta f_i}(P_{i+1} - P_i)$$

This leads to:

$$emission\_rel_{it} = 10\log\left\{\sum_{i=0}^{N-1}\int_{\Delta f_i}^{\Delta f_{i+1}} 10^{\frac{P_{rel}^{dBc}(\Delta f)}{10}} d\Delta f\right\}$$

where:

$$\Delta f_0 = a = f_{vr} - f_{it} - B_{vr}/2$$

$$\Delta f_N = b = f_{vr} - f_{it} + B_{vr}/2$$

Intermediate calculation

$$emission\_rel_i^{dBc} = \int_{\Delta f_i}^{\Delta f_{i+1}} 10^{\frac{P_{rel}^{dBc}(\Delta f)}{10}} d\Delta f$$

$$emission\_rel_i^{dBc} = 10^{\frac{P_i}{10}}\int_{\Delta f_i}^{\Delta f_{i+1}}\left[10^{\frac{P_{i+1}-P_i}{10(\Delta f_{i+1}-\Delta f_i)}}\right]^{(\Delta f - \Delta f_i)} d\Delta f$$

$$emission\_rel_i^{dBc} = \frac{10^{\frac{P_i}{10}}}{K^{\Delta f_i}}\int_{\Delta f_i}^{\Delta f_{i+1}} K^{(\Delta f - \Delta f_i)} d\Delta f, K = 10^{\frac{P_{i+1}-P_i}{10(\Delta f_{i+1}-\Delta f_i)}}$$

$$emission\_rel_i^{dBc} = \frac{10^{\frac{P_i}{10}}}{K^{\Delta f_i}}\left[e^{\ln K}\right]_{\Delta f_i}^{\Delta f_{i+1}} = \frac{10^{\frac{P_i}{10}}}{\ln K}\left[K^{\Delta f_{i+1}-\Delta f_i} - 1\right], \ln K = \frac{\ln 10}{10}\cdot\frac{P_{i+1}-P_i}{\Delta f_{i+1}-\Delta f_i}$$

$$emission\_rel_i^{dBc} = \frac{10}{\ln 10}\frac{10^{P_{i+1}} - 10^{P_i}}{P_{i+1} - P_i}(\Delta f_{i+1} - \Delta f_i)$$

Eventually:

$$emission\_rel_{it} = 10\log\left\{\frac{10}{\ln 10}\sum_{i=0}^{N-1}\frac{\left(P_{i+1}^{linear} - P_i^{linear}\right)\left(\Delta f_{i+1} - \Delta f_i\right)}{\left(P_{i+1}^{dBc} - P_i^{dBc}\right)}\right\}$$

2 Emission floor

The aforementioned formulas are also applicable to absolute emission floor $emission\_floor_{it}$ (dBm). This emission floor mask can be described by a triplet (*frequency offset (MHz), reference bandwidth (MHz), emission floor (dBm)*).

The real emission is bounded by the emission floor by the following equation

$$emission_{it} = \max(emission\_rel_{it} + p_{it}^{\sup plied} + g_{it}^{PC}, emission\_floor_{it})$$

which is also illustrated in Fig. A10.3.

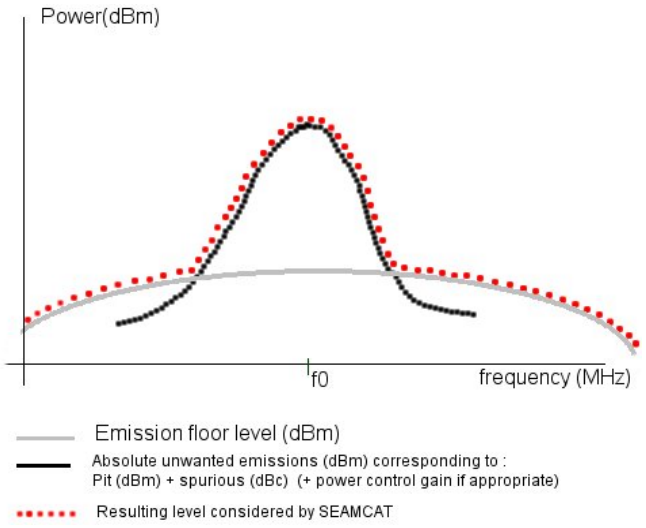

Power(dBm)
f0
frequency (MHz)
Emission floor level (dBm)
Absolute unwanted emissions (dBm) corresponding to :
Pit (dBm) + spurious (dBc) (+ power control gain if appropriate)
Resulting level considered by SEAMCAT

Figure A10.3: Resulting power level for the calculation of iRSS

Annex 11: Calculation of probability of interference

1. General principles

The ICE module is developed to calculate probability of interference based on the signals generated by the EGE. This probability of interference is seen as a function of a set of reference parameters, which, in this version of the software, are limited to the following parameters:

- unwanted emission level for each transmitter of each interfering link
- victim receiver response for blocking interference
- victim receiver intermodulation rejection

Two calculation modes can be foreseen for the ICE module:

1. Compatibility mode: evaluation of probability of interference to the victim link from one or more interfering links operating in the same or/and in adjacent bands. In this case the reference parameters are considered to be a function of victim link's and interfering link's frequencies f_{Vr} and f_{It}.

2. Translation mode: calculation of the probability of interference as a function of one of the reference parameters, varying in the limits set by the user in ICE dialog window. In this case the reference parameters are considered to be not frequency dependent.

The probability of interference itself may be calculated in SEAMCAT using one of three available algorithms:

1. **Quick algorithm –** the algorithm with shortest computation time; this algorithm may be used if dRSS and iRSS signals are not correlated AND if either there is only one iRSS signal or there is one dominant iRSS signal in a scenario with more than one interferer;

2. **Complete 1 algorithm** – to be used when there is strong correlation between dRSS and iRSS signals;

3. **Complete 2 algorithm** – may be used instead of Quick algorithm in case of non-correlated dRSS and iRSS signals when:
   a. it is not possible to use Quick algorithm because of no assumption can be made on the dominance of one of iRSS signals in case of scenario with more than one interfering system, or
   b. wishing to achieve more precision.

2. Computation principles

2.1. For the Unwanted: I = power supplied It + $iRSS_{unwanted}$

The probability equals 0 when the criteria verify for all sample

- C/I or C/(N+I) calculated > C/I or C/(N+I) input, or
- (N+I)/N or I/N calculated < (N+I)/N or I/N input

The probability equals 1 when the criteria verifies for all sample

- C/I or C/(N+I) calculated < C/I or C/(N+I) input, or
- (N+I/N) or I/N calculated > (N+I)/N or I/N input

e.g.

N+I/N = 10*LOG{[10^(I/10) + 10^(N)] / 10^(N)}= (N+I)/N input

(with I and N in dB)

Power supplied IT = 10 LOG{ [(10^(input value/10)) –1] 10^(N/10)} – $iRSS_{unwanted}$

Then checking some point of the translation curve is possible with for instance max and min $iRSS_{unwanted}$.

2.2. For the blocking: I = Blocking response level + iRSSblock

The probability equals 0 when the criteria verifies for all sample

- C/I or C/(N+I) calculated > C/I or C/(N+I) input, or
- (N+I)/N or I/N calculated < (N+I)/N or I/N input

The probability equals 1 when the criteria verifies for all sample

- C/I or C/(N+I) calculated < C/I or C/(N+I) input, or
- (N+I/N) or I/N calculated > (N+I)/N or I/N input

e.g.

N+I/N = 10*LOG{[10^((I)/10) + 10^(N)] / 10^(N)}= input value

(with I and N in dB)

Blocking response level =-(10 LOG{ [(10^(input value/10)) –1] 10^(N/10)} – $iRSS_{block}$)

Then checking some point of the translation curve is possible with for instance max and min $iRSS_{block}$.

Annex 12: Power control function

Power control gain for the interfering transmitter:

$$g_{it\ PC} = f_{pc}\left(p_{it\ supplied}, g_{it\ -\!>wr}, pl_{it-\!>wr}, g_{wr\ -\!>it}, pc_{threshold\_rg}, pc_{dyn\_rg}, pc_{step\_rg}\right)$$

where:

$p_{it\ supplied}$	Power supplied by the interferer before power control;
$g_{it\ -\!>wr}$	Interfering transmitter antenna gain in wanted receiver direction;
$g_{wr\ -\!>it}$	Wanted receiver antenna gain in interfering transmitter direction;
$pl_{it\ -\!>wr}$	path loss between the It and the Wr;
$pc_{threshold\_rg}$	power control receiver threshold, if the received power is lower than this threshold, then no power control takes place (dBm)
pc_{dyn_rg}	power control dynamic range (dB)
pc_{step_rg}	steps of power control (dB)

The power received in the wanted receiver results in:

$$p = p_{it\ supplied} + g_{it\ PC} + g_{it\ -\!>wr} - pl_{it-\!>wr} + g_{wr\ -\!>it}$$

Three states of applying power control are possible:

Case 1 (received power below power threshold):

$$p \leq pc_{hold}$$

$$g_{it\ PC} = 0$$

Case 2 (within power control limits):

$$pc_{hold} + (i\text{-}1)\, pc_{step} \leq p < pc_{hold} + i\ pc_{step}$$

$$g_{it\ PC} = -(i\text{-}1)\ pc_{step}$$

where i is an integer ranging from 1 to $n\_step = (pc_{dyn}) / (pc_{step})$

Case (beyond power control limits):

$$p \geq pc_{hold} + pc_{dyn}$$

$$g_{it\ PC} = - pc_{dyn}$$

Annex 13: Use of dBc attenuation units

1 Definition

The ITU-R Recommendation on Out-of-Band Emission Limits provides a definition of dBc unit, which is defined as "Decibels relative to the unmodulated carrier power of the emission. In the cases which do not have a carrier, for example in some digital modulation schemes where the carrier is not accessible for measurement, the reference level equivalent to dBc is decibels relative to the mean power P."

2 Examples of calculation using dBc

The Recommendation ITU-R SM.329 dealing with Spurious Emissions provides two examples of calculations using dBc unit, the two examples described below are based on those provided in this recommendation.

2.1 Example 1

A land mobile transmitter, with any value of necessary bandwidth, must meet an attenuation of $43 + 10 \log P$, or 70 dBc, whichever is less stringent. To measure the emissions the use of a reference bandwidth of 100 kHz is recommended.

With a measured total mean power of 10 W:

Attenuation relative to total mean power = $43 + 10 \log 10 = 53$ dB

The 53 dBc is less stringent than 70 dBc, so the 53 dBc value is used. Therefore, emissions must not exceed 53 dBc in a 100 kHz reference bandwidth, or converting to an absolute level: 10 dBW – 53 dBc = – 43 dBW in a 100 kHz reference bandwidth.

With a measured total mean power of 1 000 W:

Attenuation relative to total mean power = $43 + 10 \log 1\,000 = 73$ dB

The 73 dBc is more stringent than 70 dBc limit, so the 70 dBc value is used. Therefore, emissions must not exceed 70 dBc in a 100 kHz reference bandwidth, or converting to an absolute level: 30 dBW – 70 dBc □ – 40 dBW in a 100 kHz reference bandwidth.

2.2 Example 2

A space services transmitter, with any value of necessary bandwidth, must meet an emission attenuation of $43 + 10 \log P$, or 60 dBc, whichever is less stringent. To measure the emissions it is recommended to use a reference bandwidth of 4 kHz.

With a measured total mean power of 20 W:

Attenuation relative to total mean power = $43 + 10 \log 20 = 56$ dB

The 56 dBc is less stringent than the 60 dBc limit, so the 56 dBc value is used. Therefore, emissions must not exceed 56 dBc in a 4 kHz reference bandwidth or converting to an absolute level: 13 dBW – 56 dBc = – 43 dBW in a 4 kHz reference bandwidth.

3 Example of dBc emission mask

The following range of attenuation is considered, for a system of 30dBm using a 20kHz necessary bandwidth. The reference bandwidth for the attenuation is 10kHz.

Within the necessary bandwidth the reference bandwidth is taken equal to the necessary bandwidth.

Frequency offset	Attenuation in dBc	Attenuation in dBc	Attenuation in dBc in Seamcat mask
0 to 10 kHz	0	0 dBc	0 dBc
10 to less than 20 kHz	Min (p(dBW)+30, 36)	30 dBc	-30 dBc
20 to less than 30 kHz	Min (p(dBW) + 40, 36)	36 dBc	-36 dBc
30 to less than 40 kHz	Min (p(dBW) + 45, 40)	40 dBc	-40 dBc
40 to less than 50 kHz	50	50 dBc	-50 dBc

Figure 1, shows the "upper" part of the mask derived from the table 1, the whole mask is symmetric. It should be noted that the frequency offset should be defined in MHz.

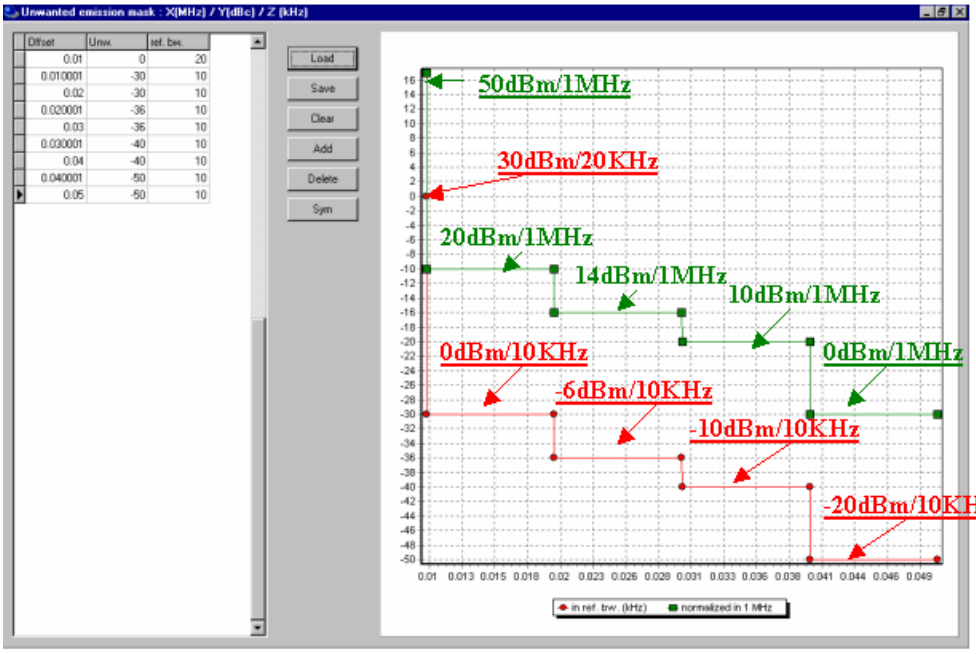


Figure A13.1: Example of "Upper part" of an Emission Mask in dBc

If the mask is symmetric, the whole mask may be obtained by using the Sym function.

In the following Fig. 2, N1 and N2 correspond to the same level of power and correspond to attenuations defined in dBc given in reference bandwidth (kHz) and normalized bandwidth (1MHz) respectively.

N1(dBm/Bref) = P(dBm) + Att_1(dBc/Bref)

N2(dBm/1MHz) = P(dBm) + Att_2(dBc/1MHz)

Where P is the Power within the necessary bandwidth.

N1(dBm/Bref) and N2(dBm/1MHz) represent the same level of power (P_i):

P_i (dBm) = N1(dBm/Bref) + 10*$\log_{10}$ (Bref)

P_i (dBm) = N2(dBm/1MHz) + 10*$\log_{10}$ (1MHz)

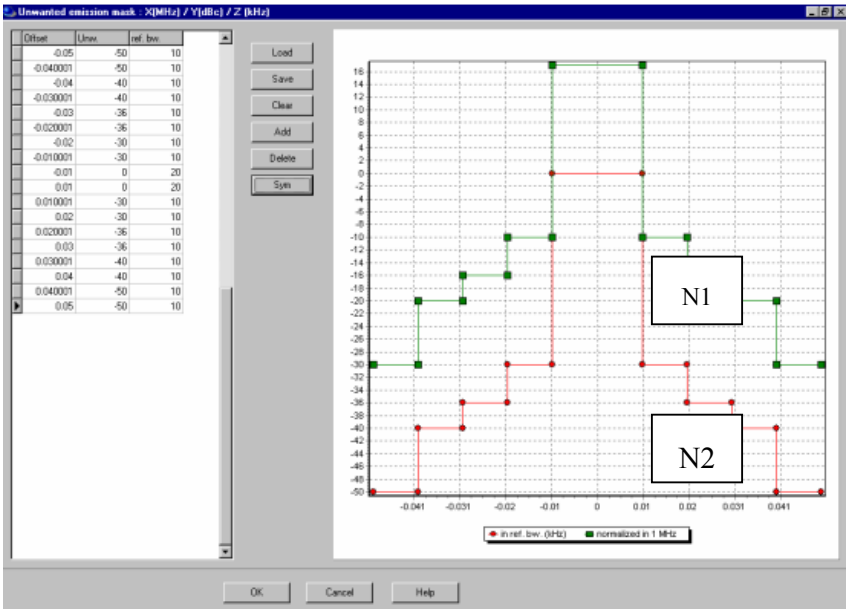


Figure A13.2: Link between the normalised mask and the mask given in reference bandwidth

Therefore the relation between the attenuations in dBc defined in reference bandwidth and in 1MHz respectively is given by:

Delta = N1(dBm/1MHz)–N2(dBm/Bref))

Delta = P_i (dBm) - 10*$\log_{10}$ (Bref) – (P_i (dBm) - 10*$\log_{10}$ (1MHz))

Delta = 10*$\log_{10}$[(1MHz)/(Bref)]

Note 1:

- If the reference bandwidth is larger than the emission bandwidth then the attenuation must be defined with positive sign;
- If the reference bandwidth is lower than the emission bandwidth then the attenuation must be defined with negative sign;
- If the reference bandwidth is equal to the emission bandwidth then the attenuation should be set up at zero.

Note 2: SEAMCAT conducts a consistent check on the emission mask, then the emission mask should be defined to cover the frequency range where the Victim Receiver is defined. SEAMCAT displays a warning when the emission mask is not properly defined.

Annex 14: Document history

Software version	Manual version	Introduced changes
2.1.0	March 2003	Original version of User Manual, based on previous "SEAMCAT User Documentation"
2.1.0	8 April 2003	Editorial corrections in sections 2.4.3, 5, Annexes 4, 9, 10 and 12 to make text more clear, remove some redundancies. Additional warning in Annex 7 (p. 60). No functional changes reflected.
2.1.0	2 June 2003	Clarification added to section 2.3 of Annex 9. In Annex 11 the Fig. A11.1 replaced with the new text placed as section A11.1 on the choice of ICE algorithms.
2.1.0	3 September 2003	Clarifications to description of DEE (p.8), parameter of dynamic receive power (p. 25), editorials re. "Indoor-indoor" model (p.53-54), intermodulation bug warning (p.74).
2.1.0	8 January 2004	Revised example in section 2.3.2 (incl. replaced Figs. 12 and 13), to avoid the impact of bug with the discrete uniform distribution, used in that example in previous versions of manual.
2.1.0	23 February 2004	Revised Annex 4, to explain better the calculation of blocking. A warning added in section A6.2, An.6.